Geol Survey

Guide to the Geology of the Galena Area

Jo Daviess County, Illinois
Lafayette County, Wisconsin

David L. Reinertsen

Field Trip Guidebook 1992B May 16, 1992
Department of Energy and Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY

Cover photos by D. L. Reinertsen

Clockwise from upper left: Silurian dolomite cap on Scales Mound, early crevice mine south of Galena near the Mississippi River, and downtown Galena as viewed from the old Galena High School.

Geological Science Field Trips The Educational Extension Unit of the Illinois State Geological Survey (ISGS) conducts four free tours each year to acquaint the public with the rocks, mineral resources, and landscapes of various regions of the state and the geological processes that have led to their origin. Each trip is an all-day excursion through one or more Illinois counties. Frequent stops are made to explore interesting phenomena, explain the processes that shape our environment, discuss principles of earth science, and collect rocks and fossils. People of all ages and interests are welcome. The trips are especially helpful to teachers who prepare earth science units. Grade school students are welcome, but each must be accompanied by a parent or guardian. High school science classes should be supervised by at least one adult for each ten students.

A list of guidebooks of earlier field trips for planning class tours and private outings may be obtained by contacting the Educational Extension Unit, Illinois State Geological Survey, Natural Resources Building, 615 East Peabody Drive, Champaign, IL 61820. Telephone: (217) 244-2407 or 333-7372.

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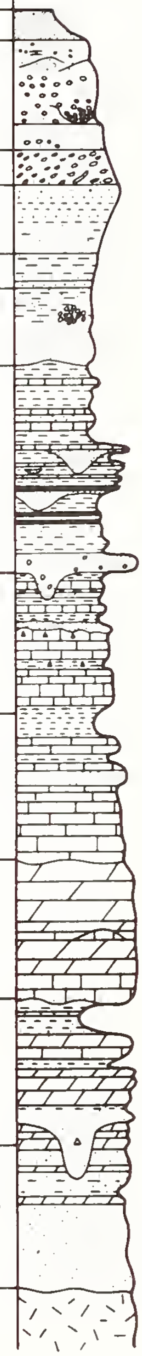
ILLINOIS STATE GEOLOGICAL SURVEY
Morris W. Leighton, Chief
Natural Resources Building
615 East Peabody Drive
Champaign, IL 61820

CONTENTS

FIGURES

Era		Period or System and Thickness	Epoch	Age (years ago)	General Types of Rocks
CENOZOIC "Recent Life"	Age of Mammals	Quaternary 0–500'	Holocene	10,000	Recent – alluvium in river valleys
			Pleistocene Glacial Age	1.6 m.	Glacial till, glacial outwash, gravel, sand, silt, lake deposits of clay and silt, loess and sand dunes ; covers nearly all of state except northwest corner and southern tip
		Tertiary 0–500'	Pliocene	5.3 m.	Chert gravel, present in northern, southern, and western Illinois
			Eocene	36.6 m. – 57.8 m.	Mostly micaceous sand with some silt and clay; present only in southern Illinois
			Paleocene	66.4 m.	Mostly clay, little sand; present only in southern Illinois
MESOZOIC "Middle Life"	Age of Reptiles	Cretaceous 0–300'		144 m. – 286 m.	Mostly sand, some thin beds of clay and, locally, gravel; present only in southern Illinois
PALEOZOIC "Ancient Life"	Age of Amphibians and Early Plants	Pennsylvanian 0–3,000' ("Coal Measures")		320 m.	Largely shale and sandstone with beds of coal, limestone, and clay
		Mississippian 0–3,500'		360 m.	Black and gray shale at base; middle zone of thick limestone that grades to siltstone, chert, and shale; upper zone of interbedded sandstone, shale, and limestone
	Age of Fishes	Devonian 0–1,500'		408 m.	Thick limestone, minor sandstones and shales; largely chert and cherty limestone in southern Illinois ; black shale at top
	Age of Invertebrates	Silurian 0–1,000'		438 m.	Principally dolomite and limestone
		Ordovician 500–2,000'		505 m.	Largely dolomite and limestone but contains sandstone, shale, and siltstone formations
		Cambrian 1,500–3,000'		570 m.	Chiefly sandstones with some dolomite and shale; exposed only in small areas in north-central Illinois
ARCHEOZOIC and PROTEROZOIC					Igneous and metamorphic rocks; known in Illinois only from deep wells



〰 major unconformity

Generalized geologic column showing succession of rocks in Illinois.

GALENA AREA

The mineral, galena (lead sulfide, PbS), for which the largest city in Jo Daviess County is named, was the focus of much prospecting and mining in extreme northwestern Illinois during the first half of the 1800s. Lead ore played a large role in the economic development, not only of the Galena area, but also of Illinois. Considerable wealth, amassed by many of the early settlers and developers, gave rise to Galena's impressive homes and businesses. The amalgamation of architectural styles, natural setting, people, and mineral resources created the distinctive charm of this part of Illinois.

In 1800, 95% of our nation's population lived east of the Appalachian Mountains. During the early part of the last century, thousands of people had moved west and north seeking cheap, abundant land, and the Illinois Territory and Galena area experienced a boom in population growth. The population of the Illinois Territory in 1810 was 12,282. In 1820, 2 years after statehood, our population had increased to 55,162. By 1830, it had rapidly grown to 157,445, and by 1840, it had swelled to 476,183. During this period, the Galena area experienced a sort of "lead rush," similar to later gold rushes.

The landscape, geology, and mineral resources surrounding the city of Galena are the subjects of this field trip. The area's rugged surface, one of the most scenic landscapes in the state, was formed mainly by differential erosion of Ordovician and Silurian sedimentary strata (see rock succession column on facing page) consisting primarily of dolomite and shale, and some limestone. Ridges are upheld by resistant dolomite caps, and slopes are developed on soft shale. Steep-walled valleys are incised into lower, older, resistant dolomite strata.

The city of Galena lies approximately 160 miles west-northwest of Chicago, 210 miles north-northwest of Springfield, and 290 miles north-northwest of East St. Louis.

Structural and Depositional History

Precambrian Era The Jo Daviess County area, like the rest of present-day Illinois, has undergone many changes through several billion years of geologic time. The oldest rocks beneath the field trip area belong to the ancient Precambrian (Archeozoic and Proterozoic) basement complex. We know relatively little about these rocks from direct observations because they are not exposed at the surface anywhere in Illinois. Only about 30 holes have been drilled deep enough in our state for geologists to collect samples from Precambrian rocks; depths range from about 2,100 feet in the Galena region to about 13,000 to 17,000 feet in southern Illinois. From these samples, however, we know that the ancient rocks consist mostly of granitic and possibly metamorphic, crystalline rocks that formed about 1.5 to 1.0 billion years ago when molten igneous materials slowly solidified within the earth. By about 0.6 billion years ago, deep weathering and erosion had exposed the ancient rocks at the surface, forming a landscape probably quite similar to part of the present-day Missouri Ozarks. We have no rock record in Illinois for the long interval of weathering and erosion that lasted from the time Precambrian rocks were formed until Cambrian sediments were deposited across the older land surface; that interval, however, is longer than geologic time from the Cambrian to the present!

Geologists seldom see Precambrian rocks except as cuttings from drill holes. To determine some of the characteristics of the basement complex, they use various techniques, including surface mapping, measurements of Earth's gravitational and magnetic fields, and seismic tests. The evidence indicates that rift valleys similar to those in east Africa formed in what is now southernmost Illinois during the late Precambrian Era. These midcontinental rift structures, known as the Rough Creek Graben and the Reelfoot Rift (fig. 1), formed when plate tectonic movements (slow global deformation) began to rip apart an ancient Precambrian supercontinent that had formed earlier when various ancient landmasses came together. (Continental collision is going on today as the Indian subcontinent moves northward against Asia, folding and lifting the Himalayas.) The slow fragmentation of the Precambrian supercontinent eventually isolated a new landmass, called Laurasia, which included much of what is now the North American continent.

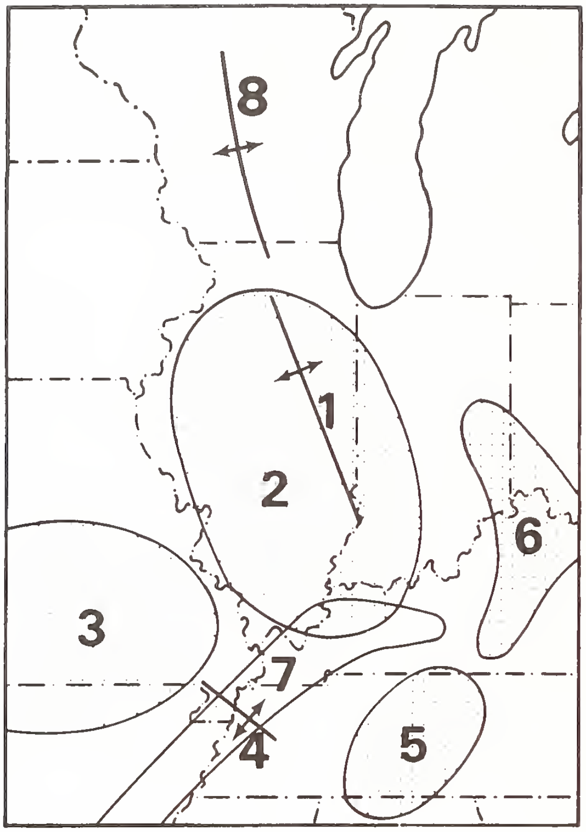


Figure 1 Location of some of the major structures in the Illinois region. (1) La Salle Anticlinal Belt, (2) Illinois Basin, (3) Ozark Dome, (4) Pascola Arch, (5) Nashville Dome, (6) Cincinnati Arch, (7) Rough Creek Graben-Reelfoot Rift, and (8) Wisconsin Arch.

Near the end of the Precambrian Era and continuing until late Cambrian time, about 570 million to 505 million years ago, tensional forces within the earth apparently caused block faulting and relatively rapid subsidence of the hilly landscape on a regional scale. This permitted the invasion of a shallow sea from the south and southwest.

Paleozoic Era During the Paleozoic Era, what is now southern Illinois continued to sink slowly and to accumulate sediments deposited in shallow seas that repeatedly covered the area. At least 15,000 feet of sedimentary strata accumulated during the 325 million years of the Paleozoic Era. These sediments, when compacted and hardened (indurated), and the underlying Precambrian rocks constitute the bedrock succession. Bedrock refers to the indurated or lithified rock units that underlie the soils or other relatively loose, crumbly, materials near Earth's surface.

In Jo Daviess County, the field trip area is underlain by nearly 2,500 feet of Paleozoic sedimentary strata, ranging from deeply buried rocks of late Cambrian age (about 523 million years old) to surface exposures of lower Silurian age (about 423 million years old). From middle Ordovician time about 460 million years ago, until the end of the Permian Period (and the Paleozoic Era) about 245 million years ago, the area that is now Illinois, Indiana, and western Kentucky, sank more slowly than it did earlier. Repeatedly, sediments poured into a broad trough or embayment covering the area, and overflowed into surrounding areas as well. Because of compressive and stretching forces that developed at various times, Earth's thin crust has frequently been flexed and warped in various places. These recurrent movements over millions of years caused the seas to periodically drain from the region and slowly return. When the sea floors were uplifted and exposed to weathering and erosion by rain, wind, and streams, some of the previously deposited strata were eroded. Consequently, not all geologic intervals are represented in the rock record in Illinois (see the generalized geologic column opposite page 1).

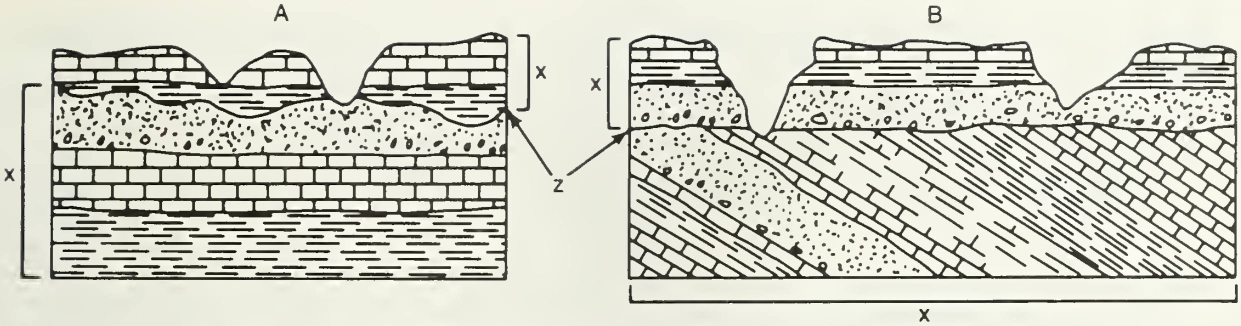


Figure 2 Schematic drawings of (A) a disconformity and (B) an angular unconformity (x represents the conformable rock sequence and z is the plane of unconformity).

Stratigraphic units and contacts Sedimentary rock, such as limestone, sandstone, shale, or combinations of these and other rock types, commonly occur in units called formations. A formation is a body of rock that has a distinctive lithology, or set of characteristics, and easily recognizable top and bottom boundaries. It is also thick enough to be readily traceable in the field and sufficiently widespread to be represented on a map. Most formations have formal names, such as Renault Limestone or Downeys Bluff Limestone, which are usually derived from geographic names and predominant rock types. In cases where no single rock type is characteristic, the word Formation becomes a part of the name. A group is a vertical lumping together of adjacent formations having many similarities. A member, or bed, is a subdivision of a formation that is too thin to be classified as a formation or that has minor characteristics setting it apart from the rest of the formation.

Many formations have conformable contacts where no significant interruptions took place in the deposition of the sediments that formed the rock units. In such instances, even though the composition and appearance of the rocks changes significantly at the contact between two formations, the fossils in the rocks and the relationships between the rocks at the contact indicate that deposition was essentially continuous. At other contacts, however, the lower formation was subjected to weathering and at least partly eroded before the overlying formation was deposited. In these cases, the fossils and other evidence in the formations indicate the presence of a significant gap between the time when the lower unit was deposited and the time when the overlying unit was laid down. This type of contact is called an unconformity. Where the beds above and below an unconformity are essentially parallel, the unconformity is called a disconformity (fig. 2a); where the lower beds were tilted and eroded before the overlying beds were deposited, the contact is called an angular unconformity (fig. 2b). Major unconformities are indicated on the geologic column opposite page 1; each represents a long interval of time during which a considerable thickness of rock, present in nearby regions, was either eroded or never deposited in parts of this area. Several smaller unconformities are also present. They represent shorter time intervals and thus smaller gaps in the depositional record.

Ordovician Period The oldest rock exposed on the field trip is the middle Ordovician shale of the Spechts Ferry Formation, the basal formation of the Galena Group (fig. 3), which formed from sediments deposited in the embayment that encompassed present-day Illinois about 468 million years ago. Most of the remaining Galena Group strata are dolomite (calcium magnesium carbonate, $CaMg(CO_3)_2$) that was originally deposited as limestone ($CaCO_3$) in the shallow seas of the embayment that covered what is now Illinois and adjoining states. The limestone was later altered to dolomite. The total thickness of the Galena Group is about 245 feet. The upper Ordovician Maquoketa Shale Group unconformably overlies the Galena Group. The mud that produced the shale was flushed into shallow areas from nearby low-lying land areas. These shales are the youngest Ordovician rocks and are about 200 feet thick.

Silurian Period The youngest Ordovician strata were partially eroded before early Silurian sediments accumulated in shallow seas covering what is now northwesternmost Illinois. Nearby low-lying lands generally did not contribute much sediment to the seas covering the region from

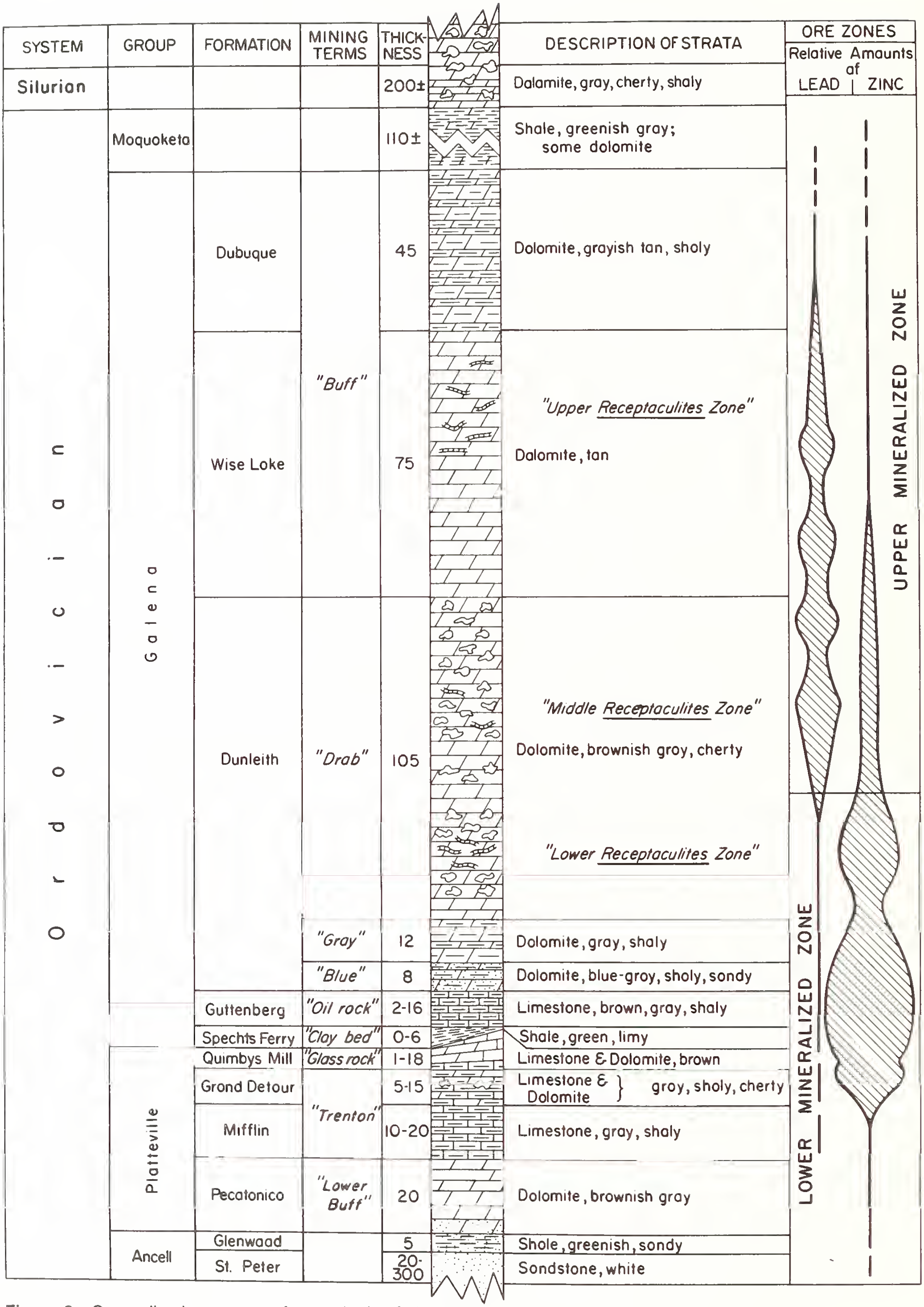


Figure 3 Generalized sequence of strata in the Galena area.

438 to about 420 million years ago. Most of the sediment deposited during this period consisted of limestone formed primarily from the shells of living organisms, both animals and plants. Early Silurian dolomite, which is the resistant caprock (top layer of rock) of the high ridges in the field trip area, reaches a thickness of about 140 feet. A greater thickness of Silurian strata may have been present across the area, but subsequent erosion removed it. Furthermore, still younger rocks may also have been present, but long periods of erosion may have removed them as well.

Regionally, the bedrock strata essentially are flat-lying, although there is a slight tilt of about 16 feet per mile to the south-southwest away from the Wisconsin Arch (figs. 1 and 4). The area's major structural features consist of low-amplitude northeast-trending synclines (downward arches) formed by a northwest-southeast compressive force. An east-west, preexisting joint system seems to have dissipated the shearing component of the northwest-southeast compressive force by yielding along fracture zones that were later favorable for ore deposition. Bradbury (1960) postulated that the staggered (en echelon) arrangement of north-northwest-trending smaller synclines and ore bodies may have formed as a result of a set of localized forces, such as might be created by a strike-slip (horizontal displacement) fault in the basement rocks.

Mesozoic and Cenozoic Eras After the Paleozoic Era (approximately 245 million years ago), during the Mesozoic Era, the rise of the Pascola Arch (fig. 1) in what is now southeastern Missouri and western Tennessee formed the Illinois Basin and separated it from other basins to the south. The Illinois Basin is a broad downwarp encompassing much of Illinois, southern Indiana, and western Kentucky (figs. 1, 4, and 5). Development of the Pascola Arch in conjunction with the earlier sinking of deeper parts of the area gave the basin its present asymmetrical, spoon shape. The geologic map of Illinois (fig. 6) shows the distribution of various rock systems as they occur at the bedrock surface; that is, as if all glacial, windblown, and other surface materials were removed.

During the Mesozoic and part of the Cenozoic Eras, a span of some 243 million years, and before the start of glaciation about 2 million years ago, the ancient Illinois land surface apparently was exposed to essentially continuous weathering and erosion. This erosion carved a series of deep valley systems into the gently tilted bedrock formations. All rocks except those of Precambrian age were subjected to erosion somewhere in Illinois in these valleys. As much as several thousand feet of post-Pennsylvanian bedrock strata may have been removed during this episode.

Glacial history Beginning nearly 2 million years ago, during the Pleistocene Epoch, massive sheets of ice—continental glaciers—several hundred feet thick flowed southward from centers of snow and ice accumulation in the far north and covered parts of present-day Illinois several times (fig. 7). The surface topography was considerably subdued by the repeated advance and melting of the glaciers, which scoured and scraped the old preglacial erosion surface. Exposed bedrock that was not directly eroded by the ice was indirectly affected by a drape or mantle of fine, windblown silt called loess (rhymes with bus).

North American continental glaciers reached their southernmost extent during Illinoian glaciation, from perhaps 300,000 to 175,000 years before the present. Advancing from centers of snow and ice accumulation in what is now Canada, the glaciers reached as far as the northern part of Johnson County in southern Illinois, about 345 miles south-southeast of Galena.

Figure 7 shows the extent of the various major glaciations that covered Illinois. We are located in the area marked by stippling in figure 7, in the unglaciated area known as the Wisconsin Driftless Section, or the "Driftless Area" as it is commonly called (fig. 8).

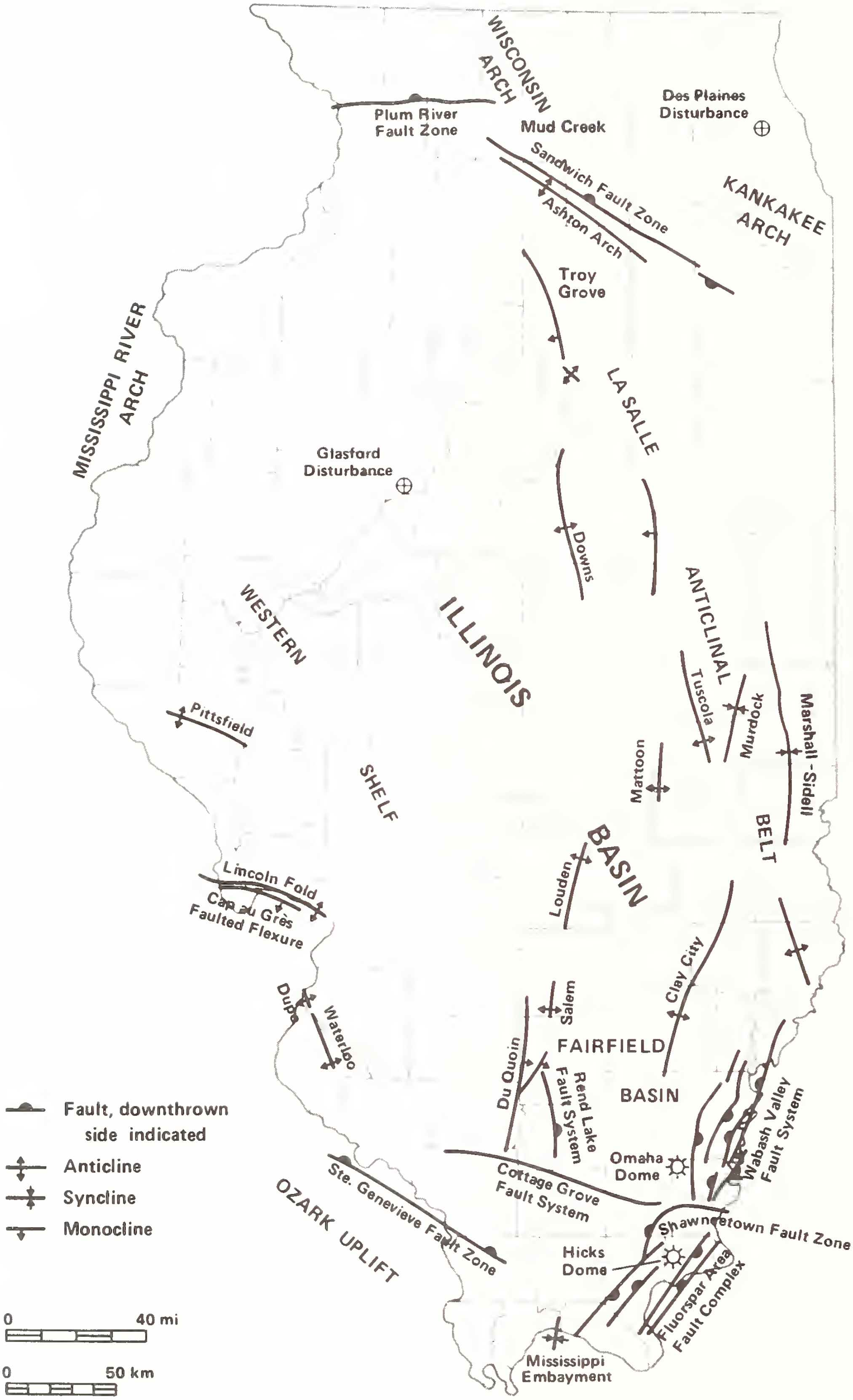


Figure 4 Structural features of Illinois.

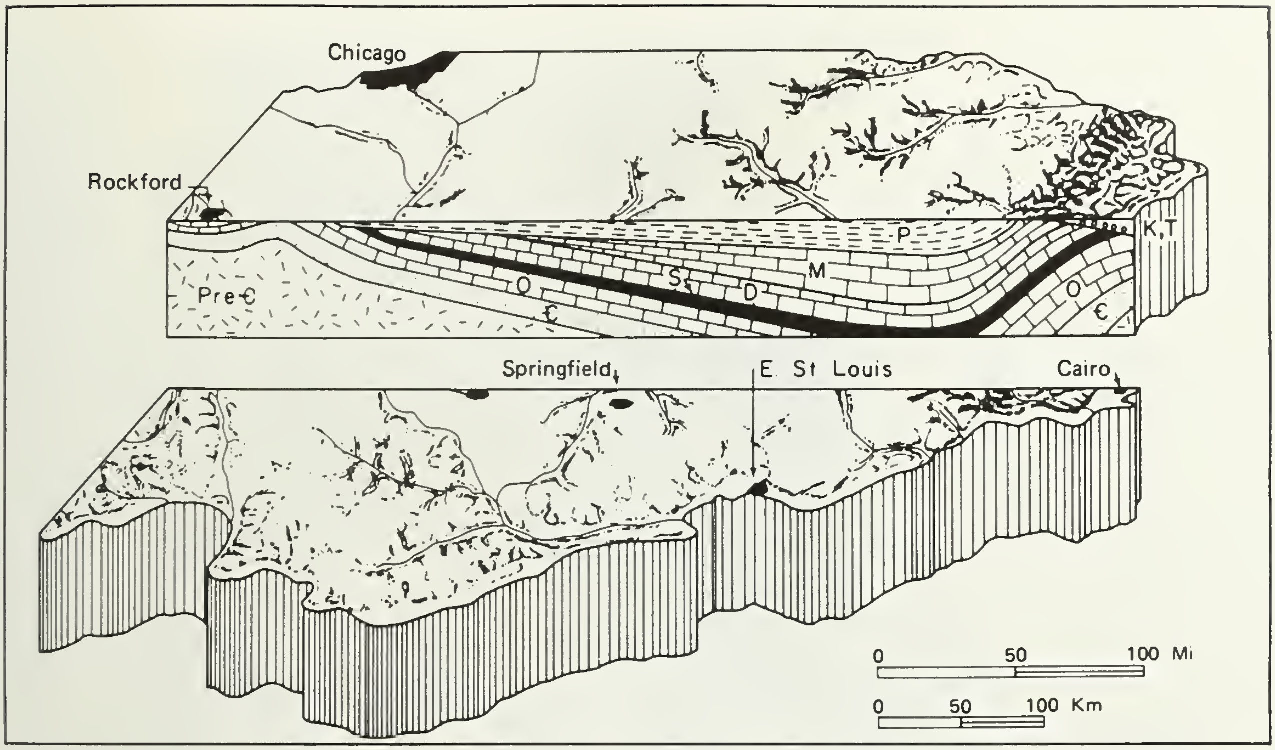


Figure 5 Stylized north-south cross section shows the structure of the Illinois Basin. To show detail, the thickness of the sedimentary rocks has been greatly exaggerated and younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre-c) granites. They form a depression filled with layers of sedimentary rocks of various ages: Cambrian (C), Ordovician (O), Silurian (S), Devonian (D), Mississippian (M), Pennsylvanian (P), Cretaceous (K), and Tertiary (T). Scale is approximate.

The closest point of the Illinoian glacial boundary is about 12 miles south-southeast of Scales Mound, the easternmost extent of our field trip. Although glaciers did not cover this area, nor did they completely surround it at any one time during the major ice advances (fig. 7), outwash deposits of silt, sand, and gravel were dumped along the Mississippi Valley. When these deposits dried out during the winters, strong prevailing winds from the northwest winnowed out the finer materials, such as fine sand and silt, and carried them eastward across the unglaciated terrain. This loess also blankets the poorly sorted till, or ground moraine (glacial drift), left behind by the glaciers. Loess up to 35 feet thick has been found in a narrow band along the uplands adjacent to the Mississippi River, but it thins away from the river to less than 12 feet thick in northeastern Jo Daviess County.

GEOMORPHOLOGY

Physiography

A physiographic province is a region in which the relief and landforms differ markedly from those in adjacent regions. The Wisconsin Driftless Section has some of the most rugged topography in Illinois. The area is a submaturely dissected, low plateau bounded by the outwash-filled valley of the Mississippi to the west and the Illinoian glacial margin on the east and southeast. Only loess, in which the modern soils are developed, mantles the deeply dissected bedrock surface. Remnants of the upland surface remain, but most of the area is in slopes. Except for the major streams, most drainage is via a system of V-shaped, steep-walled, relatively short tributaries with steep gradients (longitudinal bottom slope). Some of the minor

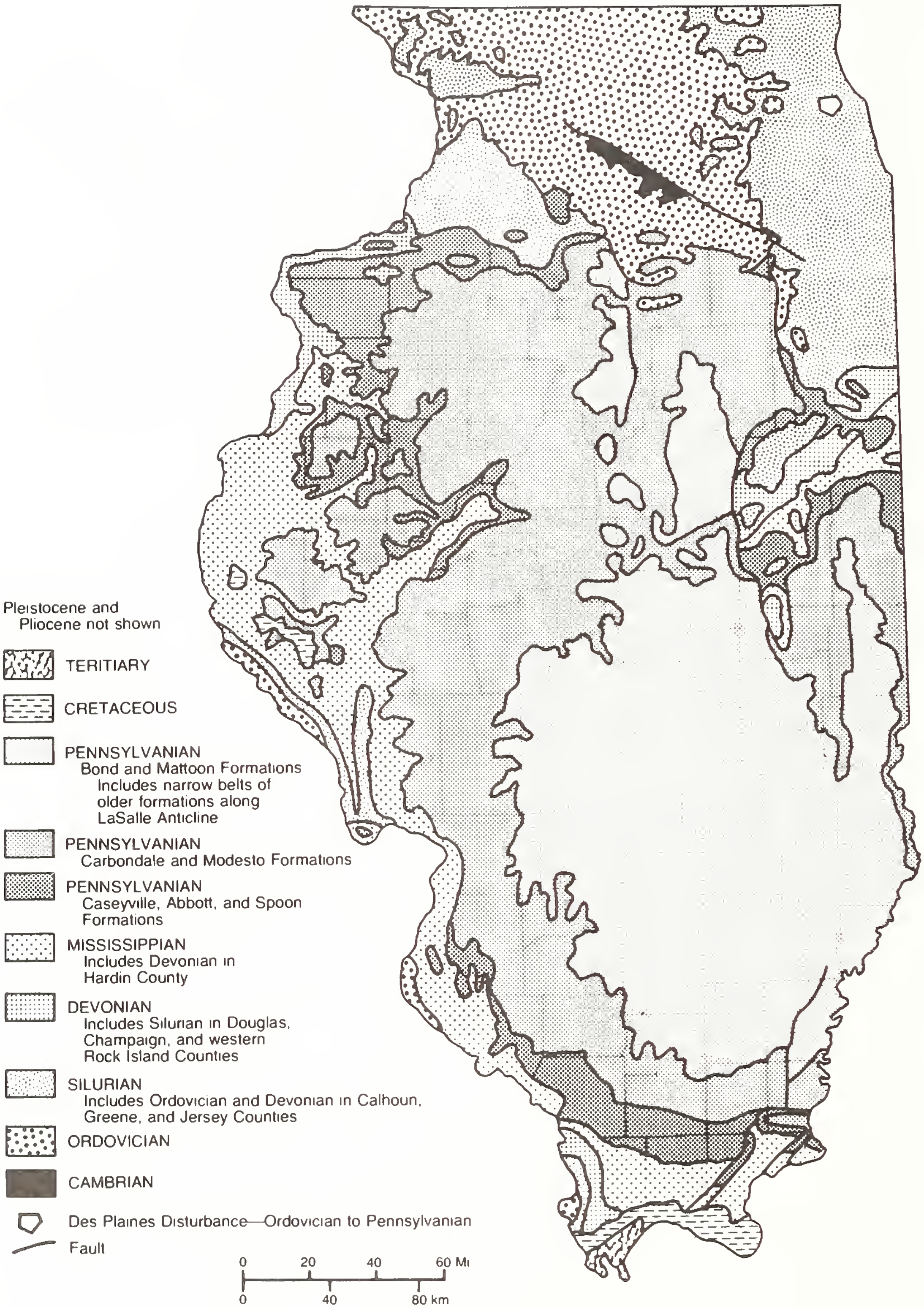


Figure 6 Bedrock geology beneath surficial deposits in Illinois.

Figure 7 Maximum extent of (a) early pre-Illinoian glaciation (about 1 million years ago), (b) late pre-Illinoian glaciation (about 600,000 years ago), (c) Illinois glaciation (about 250,000 years ago), and (d) late Wisconsinan glaciation (22,000 years ago). Driftless Area is shown by stippled pattern, and arrows indicate direction of ice movement.

tributaries have incised meanders. Sinkholes (depressions caused by dissolution of underlying dolomite) and other karst features, although present, are not conspicuous.

Drainage

The Mississippi River is the major drainageway in northwestern Illinois. Major tributaries in the Galena area include the Sinsinawa River and its tributaries on the west, and the Galena River and its tributaries, Hughlett Branch and East Fork, on the east. These tributaries drain south and west into the Mississippi. Smallpox Creek and its tributaries flow southwest to the Mississippi. Part of the field trip route is along the divide south of Galena. Here, ravines drain east and southeast to Irish Hollow, which flows south-southeast to Apple River, and from there, southwestward to the Mississippi outside of the field trip area. As noted previously, a well-developed network of smaller, V-shaped, steep-gradient tributaries has grown headward into the upland remnants. Considerable subsurface drainage occurs through small caves and solution channels that have developed in the dolomite bedrock.

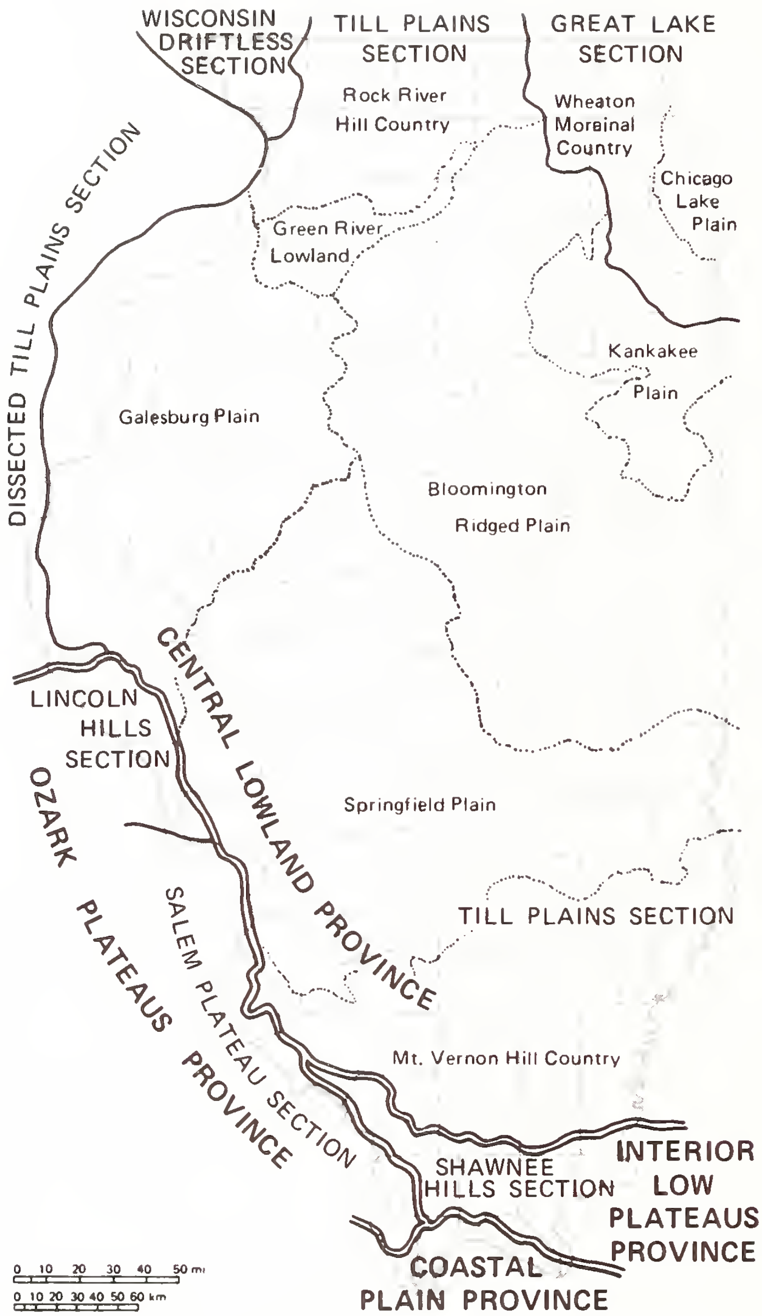


Figure 8 Physiographic divisions of Illinois.

Relief

Relief is defined as the vertical difference in elevation between the hilltops or mountain summits and the lowlands or valley bottoms of a particular area. The highest point along the Galena field-trip route is 1,142 feet above mean sea level (msl). It is in the eastern part of the area, a short distance southwest of Stop 6. The lowest elevation on the route is about 610 feet msl on the east side of the Mississippi near the base of the Chestnut Mountain Resort ski lift. Therefore, the relief along the route is 532 feet. The highest point in the area is Charles Mound north of Scales Mound with an elevation of 1,235 feet msl; this highest elevation in Illinois is 0.25 mile south of the state line. The lowest elevation in the area is the Mississippi River surface,

which has a normal pool elevation of 592 feet msl upstream from Lock and Dam No. 12 at Bellevue, Iowa. Regional relief is thus about 643 feet. Local relief is most pronounced along the Mississippi River bluffs about 6 miles south-southeast of Galena, where the elevation difference is about 380 feet in less than 0.2 mile near the Chestnut Mountain Resort. Reliefs of 200 to 250 feet in 0.25 to 0.5 mile are fairly common in this area.

MINERAL RESOURCES

Mineral Production

The field-trip route lies within the heart of the Zinc and Lead District of Northwestern Illinois. Areas of mineralization in Illinois, Iowa, and Wisconsin make up the Upper Mississippi Valley District. The Illinois portion of the district has a history of lead mining that dates from Indian mines from the late 1700s. The last commercial zinc and lead operation was closed in 1973.

Among all counties in Illinois, Jo Daviess County ranked 76th in 1989 in total value of minerals extracted—only stone and sand and gravel were mined. The stone that is produced here is used as agricultural lime, roadstone, and riprap. Of the 102 counties in Illinois, 98 reported mineral production during 1989, the last year for which complete records are available.

Jo Daviess and 14 other northern Illinois counties make up the U.S. Bureau of Mines District 1. During 1989, 55 companies with 86 operations produced almost 35 million tons of stone, excluding dimension stone, with a value of almost $135 million. Current data for sand and gravel production are not available because they are available only for even-numbered years.

During 1989, $2.84 billion worth of minerals were extracted, processed and manufactured in Illinois, an increase of $35.3 million over the previous year. The value of just the extracted minerals was $2.55 billion, an increase of 2.4% from 1988. Mineral fuels (coal, crude oil, and natural gas) made up 81.5% of the total value. Industrial and construction materials such as clay, fluorspar, sand and gravel, stone, and tripoli accounted for 18.2%. The remaining 0.3% came from metals such as lead, zinc, and silver, and from other minerals, such as peat and gemstones (Samson 1991). Illinois ranked 17th among the 50 states in total production of nonfuel minerals and continued to lead all other states in production of industrial sand, tripoli, and fluorspar.

Groundwater

Probably, few of us think of groundwater as a mineral resource when we consider the natural resource potential of an area. Yet the availability of groundwater is essential for orderly economic and community development. More than 48% of the state's 11 million citizens and 97% of those who live in rural areas depend on groundwater for their water supply.

The source of groundwater in Illinois is precipitation that infiltrates the soil and percolates into the groundwater system lying below the water table in the zone of saturation. Groundwater is stored in and transmitted through saturated earth materials called aquifers. An aquifer is any body of saturated earth materials that will yield sufficient water to serve as a water supply for some use. Pores and other void spaces in the earth materials of an aquifer must be permeable; that is, they must be large enough and interconnected so that water can overcome confining friction and move readily toward a point of discharge such as a well, spring, or seep. Generally, the water-yielding capacity of an aquifer can be evaluated by constructing wells into it. The wells are then pumped to determine the quantity and quality of groundwater available for use.

Thick permeable sand and gravel deposits occur locally in the Mississippi Valley, and some may be found in the major tributaries, especially in the lower parts of their valleys. Electrical

earth resistivity surveys (a geophysical method for characterizing buried sand and gravel deposits*) can be useful in locating groundwater supplies in these valleys.

Silurian and Ordovician dolomite units are creviced and water-bearing. Most domestic water wells in the area get their water from these formations at depths of less than 250 feet. Wells into these creviced formations are susceptible to bacterial pollution, particularly where the formation is overlain by less than 35 feet of overburden (soil and/or unconsolidated materials above the formation). Open crevices provide little filtering action and polluted water may travel long distances through these openings with little loss of pollutants.

Future of Mineral Industries in Illinois

For many years, the mineral resources of the Midcontinent have been instrumental in the development of our nation's economy. The mineral resource extraction and processing industries continue to play a prime role in our economy and in our lives, and they will continue to do so in the future. The following paragraphs tell of recent initiatives involving the Illinois State Geological Survey (ISGS) and mapping, especially in southern Illinois.

The prime mission of the ISGS is to map the geology and mineral resources of the state, conduct field mapping, collect basic geologic data in the field and in the laboratory, and interpret and compile these data on maps and in reports for use by industry, the general public, and the scientific community. Over the years, maps of the geology of the state have been published at various scales. Recently, more detailed maps and reports covering particular regions have been completed. To meet growing demands for detailed geologic information to guide economic development and environmental decision-making, the ISGS began a program to geologically map the 1,071 7.5-minute quadrangles of Illinois.

Geologic mapping of southern Illinois at the 1:24,000 scale (1 inch on the map equals nearly 0.4 mile on the ground) began with the Cave in Rock area (Baxter et al. 1963). This detailed mapping program led to a new understanding of the mineral potential for this area. In 1981, the ISGS resumed detailed mapping in southern Illinois with funding from the Nuclear Regulatory Commission (NRC). In 1984, mapping was continued with matching federal funds from the Cooperative Geologic Mapping Program (COGEOMAP) of the U.S. Geological Survey (USGS).

Recently, the U.S. Congress passed the National Geologic Mapping Act of 1991. This Act (H.R. 2763) authorizes a national program to map the geology of the United States in detail. Under the Act, the USGS will work with the 50 state geological surveys to coordinate and plan the program. Expenditures of up to $25 million annually will be matched by the states. In Illinois, similar authorizing legislation has been introduced in the General Assembly. If passed and fully funded at the state and federal levels, this program would result in completing the detailed geologic mapping of Illinois in about 20 years.

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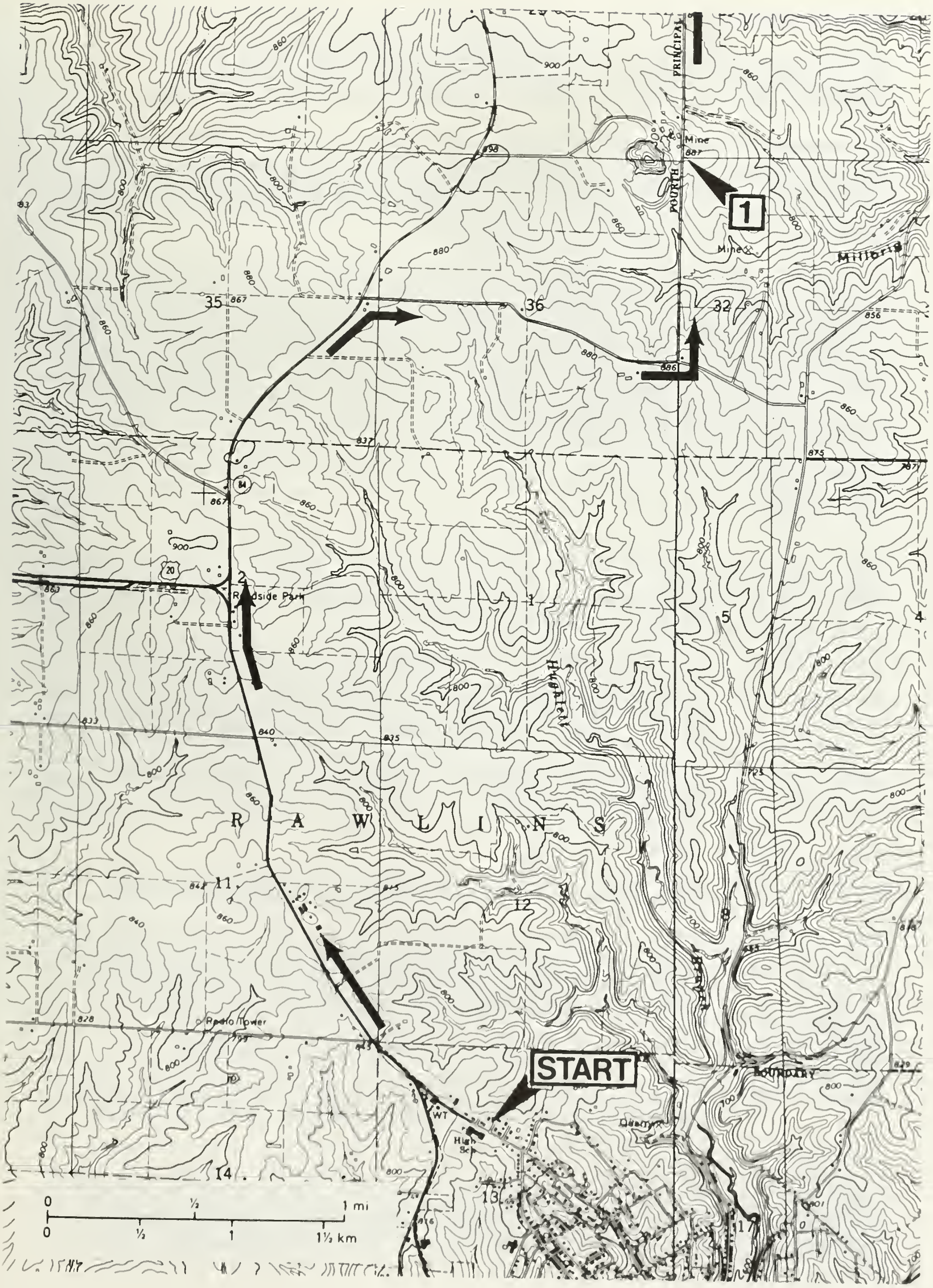
* One of the services offered by the ISGS is to perform electrical earth resistivity surveys. We do this as part of a program to help locate industrial, public, and private groundwater supplies. Resistivity surveys are useful in prospecting for buried, water-bearing sand and gravel deposits in glacial drift and alluvium overlying the bedrock. By using general geologic information about a locality and information obtained by an electrical earth resistivity survey, geologists can predict the water-bearing potential of earth materials. Since 1932, the ISGS has made more than 2,000 resistivity surveys in the state.



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GUIDE TO THE ROUTE

Assemble in the parking area on the northwest side of Galena High School (NW NW SE NW Sec. 13, T28N, R1W, 4th P.M., Jo Daviess County; Galena 7.5-Minute Quadrangle [42090D4]*). We'll start calculating mileage from the parking lot exit to North Franklin Street.

You must travel in the caravan. Please drive with headlights on while in the caravan. Drive safely but stay as close as you safely can to the car in front of you. Please obey all traffic signs. If the road crossing is protected by an emergency vehicle with flashing lights and flags, then obey the signals of the ISGS staff directing traffic. When we stop, park as close as possible to the car in front of you and turn off your lights.

Some stops on the field trip are on private property. The owners have graciously given us permission to visit on the day of the field trip only. Please conduct yourselves as guests and obey all instructions from the trip leaders. So that we may be welcome to return on future field trips, please do not litter or climb on fences. Leave all gates as you found them. These simple rules of courtesy also apply to public property. If you use this booklet for a field trip with your students, youth group, or family, you must (because of trespass laws and liability constraints) get permission from property owners or their agents before entering private property.

Miles to next point	Miles from start	
0.0	0.0	CAUTION: TURN LEFT (northwest) on North Franklin Street.
0.2+	0.2+	STOP: 1-way at Y-intersection with US 20 and State Route (SR) 84. CONTINUE AHEAD (northwest).
1.0	1.2+	The rolling landscape has developed on easily weathered shale of the Ordovician Maquoketa Shale Group that overlies the resistant dolomites of the Ordovician Galena Group. On the skyline to the right, you can see prominent ridges and mounds capped by resistant Silurian dolomite.
0.75	1.95+	CAUTION: Enter Y-intersection with US 20 and SR 84. CONTINUE AHEAD (north) on SR 84.
1.1	3.05+	Prepare to turn right.
0.1+	3.2	At the crossroads, TURN RIGHT (east) on West Council Hill Road.
0.55	3.75	Look south-southeast to southeast for three prominent mounds: Pilot Knob, 1,000+ feet msl, lies 6.4 miles to the right; Horseshoe Mound, 1,060+ feet msl, lies 4.5 miles to the left; and Dygerts Mound, 1,000+ feet msl, sits between them, 5.3 miles from here. We are about 885± feet msl.
0.55	4.3	TURN LEFT (north) on North Meridian Road at T-intersection.
0.05+	4.35+	To the right at 2:00 o'clock on the north side of Millbrig Hollow is a chat pile (waste rock) from the abandoned Graham-Ginte Mine about 0.25+ mile east of the road.

* The number in brackets [42090D4] after the topographic map name is the code assigned to that map as part of the National Mapping Program. The state is divided into 1° blocks of latitude and longitude. The first two numbers refer to the latitude of the southeast corner of the block; the next three numbers designate the longitude. The blocks are divided into sixty-four 7.5-minute quadrangles; the letter refers to the east-west row from the bottom and the last digit refers to the north-south column from the right.

0.45	4.8+	To the left is what remains of a large chat pile from the Graham Mine, Eagle Picher Mining and Smelting Company.
0.2	5.0+	PARK along the roadside. Do NOT enter the property on the west side of the road.

STOP 1 Once we've gathered along the roadside, we'll discuss the local mining, Illinois land surveys, and some of the surrounding landscape (SE SE SW SE Sec. 29, T29N, R1E, 4th P.M., Jo Daviess County; Galena 7.5-Minute Quadrangle [42090D4]).

Mining history The Upper Mississippi Valley Zinc-Lead District, an area of zinc and lead mineralization in extreme northwestern Illinois, southwestern Wisconsin, and northeastern Iowa, is one of the nation's oldest mining districts, where mines have been continuously operating since at least 1690. Jean Nicollet may have been the first white man to note the presence of lead ore in this region, as he journeyed up the Mississippi River in 1634, but this possibility is not confirmed by any record. There are reports that other French explorers had heard of Indian lead workings in the vicinity of Dubuque, Iowa, as early as 1658. Nicholas Perrot, a French commandant and Indian trader known to have viewed the Indian mines in 1682, is credited with the actual discovery of lead ore. The Indians sold lead to traders at Peoria in 1690, and in the same year, Perrot established a small temporary trading post for lead at East Dubuque. By then, the Indians had undoubtedly been mining lead from deposits near or on the surface for 100 or more years.

Commercial mining by the French and Indians continued on a small scale east of the Mississippi River for the next 100 years. In 1788, the Sac and Fox Indians gave Julien DuBuque permission to work mines on the west side of the river. DuBuque also opened a mine on the Illinois side near the site of Elizabeth. The lead mining industry continued to grow slowly until 1823, when rapid settlement of the area brought about a great expansion of the industry.

The principal lead ore mineral, galena (PbS), was so important to the area that the county seat and largest city in Jo Daviess County was named Galena in 1827. Formerly La Point, Galena was the first city in this region to organize under a charter, and it grew rapidly as the mining industry expanded. Zinc ore, sphalerite (ZnS), is also found with galena; but until about 1850 galena was the only ore recovered. Mines in the Galena vicinity were the first in the United States to produce large quantities of lead ore. In 1845, production of 27,000 tons was reported —90% of all the lead produced in the United States, then the world's leading producer.

A description of the primary minerals of this area and where they occur may be found in the section, *Zinc-Lead Deposits of Northwestern Illinois* (at the back of the guidebook).

In the early days of mining, lead ore was found primarily in rich pockets or in open vertical fissures, both referred to as "crevices." These crevices occur at or near the ground surface in the dolomite bedrock that underlies the region. Where prospecting was very intense, the land is pockmarked with shallow pits. We will pass several areas where the land has been riddled with these pits. As the mining industry expanded, rich, easily exploited crevice lodes became harder to find. The crevices were largely exhausted by 1870, and as a result, lead production sharply declined. The search for lead ore was then extended deeper into the bedrock. Some additional galena was found, but the deep ores consisted primarily of the mineral sphalerite.

The deeper ores occur in fractures in the dolomite as horizontal and inclined veins referred to as "flats" and "pitches." Sphalerite was first reported in 1839, but it was considered useless and discarded by miners in search of lead ore. When a reduction plant for zinc ore was opened near La Salle in 1852, this mineral also became important to the economic development of the mining district. From 1852 to 1909, the total production of zinc ore was greater than that of lead

ore. Although some lead ore was recovered, zinc ore was the mainstay of the region's mining industry in its later years.

The Graham Mine 0.65 mile south of here was just one of several mines along the Graham ore body, a double pitch lower-run deposit that is nearly straight, about 2,500 feet long by as much as 300 feet wide, and about 100 feet thick. This ore body, trending slightly west of north, is named the Graham-Ginte syncline for the larger mines that were developed in it. According to Willman and Reynolds (1947), the structure may be largely a solution-collapse feature. The structure is developed along a major joint system but is almost at right angles to the major axes of folding in the area. It appears to be crossed near the middle and south end by east-west-trending synclines, but it is not located along a major syncline as are the arcuate-type ore bodies that occur nearby. The Graham Mine was operated by the Vinegar Hill Zinc Company from 1916 to 1920 (fig. 9). The Ginte Mine was opened in 1943 to mine the southward continuation of the Graham ore body on the Ginte property and to take additional ore from the Graham Mine. The Bartell and Sherrill Mine, a shallow shaft into the upper part of this ore body, was located between the other two shafts. About 350,000 tons of ore were produced from this ore body from 1916 through 1945.

To the west across the road you can see what remains of a large chat pile that once lay just southwest of the site of the Graham shaft of Eagle Picher Mining and Smelting Company. According to C.O. Dale, Chief Engineer with the company, Eagle Picher first entered Illinois and began an intensive exploration program in 1946 southward from the Illinois-Wisconsin state line. They found the Graham-Snyder ore body and sank a shaft 267 feet into it in 1947-1948. When the surface plant and mill were completed, production began in 1949. During the first year of operation, 198,135 tons of ore were hoisted and milled. During the latter years of operation, the mill and surface plant here also handled ore from mines south of Galena. At one time, the chat pile here was slightly more than 0.1 mile in diameter (nearly 0.2 mile from north to south to where we first noticed it) and more than 120 feet higher than the general upland area. Its summit elevation was more than 1,000 feet msl. This imposing pile was nearly as prominent as some of the knobs and mounds in the area; it certainly dominated the landscape. Recently the stone has been removed and used mainly for road construction.

Land surveying This locality also affords the opportunity to examine the system of land surveys in Illinois. An examination of the 15- and 7.5-minute quadrangles in the field trip area shows that section lines do not show an even grid pattern over the whole area. Some sections are considerably larger than others.

In 1804, initial surveying from the 2nd P.M. (fig. 10) continued westward from Vincennes, Indiana, and became the basis for surveying about 10% of what is now eastern Illinois. Because the western boundary of this tract had not been established with certainty, it was decided in 1805 to designate the 3rd P.M. as beginning at the mouth of the Ohio River and extending northward to facilitate surveying new land cessions. By late 1805 a baseline had been run due east to the Wabash River and due west to the Mississippi River from the 3rd P.M. During March 1806, surveying commenced northward on both sides of the 3rd P.M. Sometime after the selection of an initial point from which to establish a baseline, and from which the surveys were to be laid out, the baseline was apparently arbitrarily moved northward 36 miles to just south of Centralia, where it roughly coincides with the baseline of the 2nd P.M.

The township and range system permits the accurate identification of most parcels of land in Illinois and facilitates the sale and transfer of public and private lands. In the early 1800s, each normal township was divided (to the best of the surveyor's ability) into 36 sections, each of which was 1 mile square and contained 640 acres (see route maps).

Township and range lines in figure 11 do not form a perfect rectangular grid over the state because of the use of different baselines and principal meridians, and because minor offsets were necessary to compensate for the earth's curvature. The surveying corrections producing

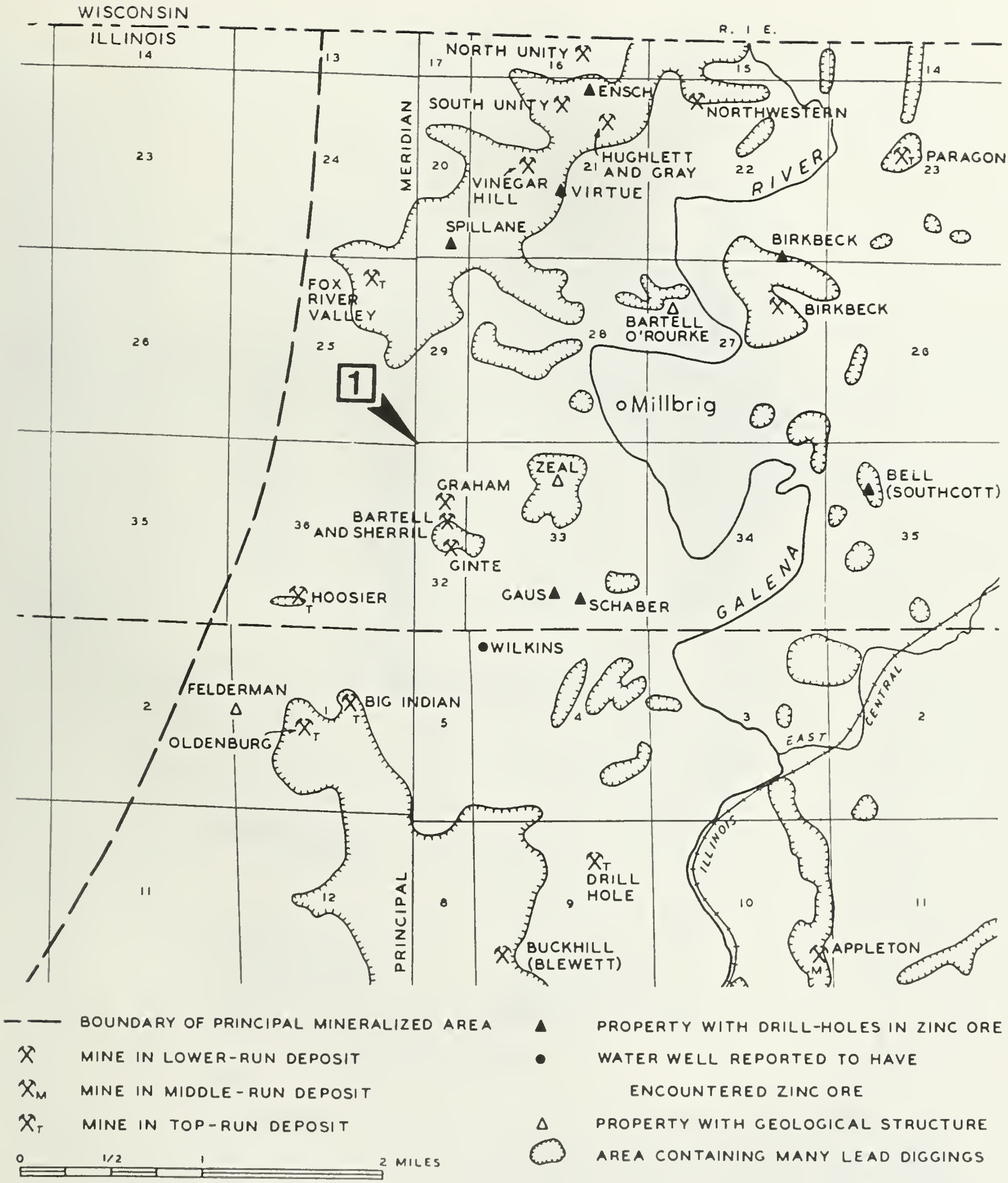


Figure 9 Zinc and lead mines near Stop 1.

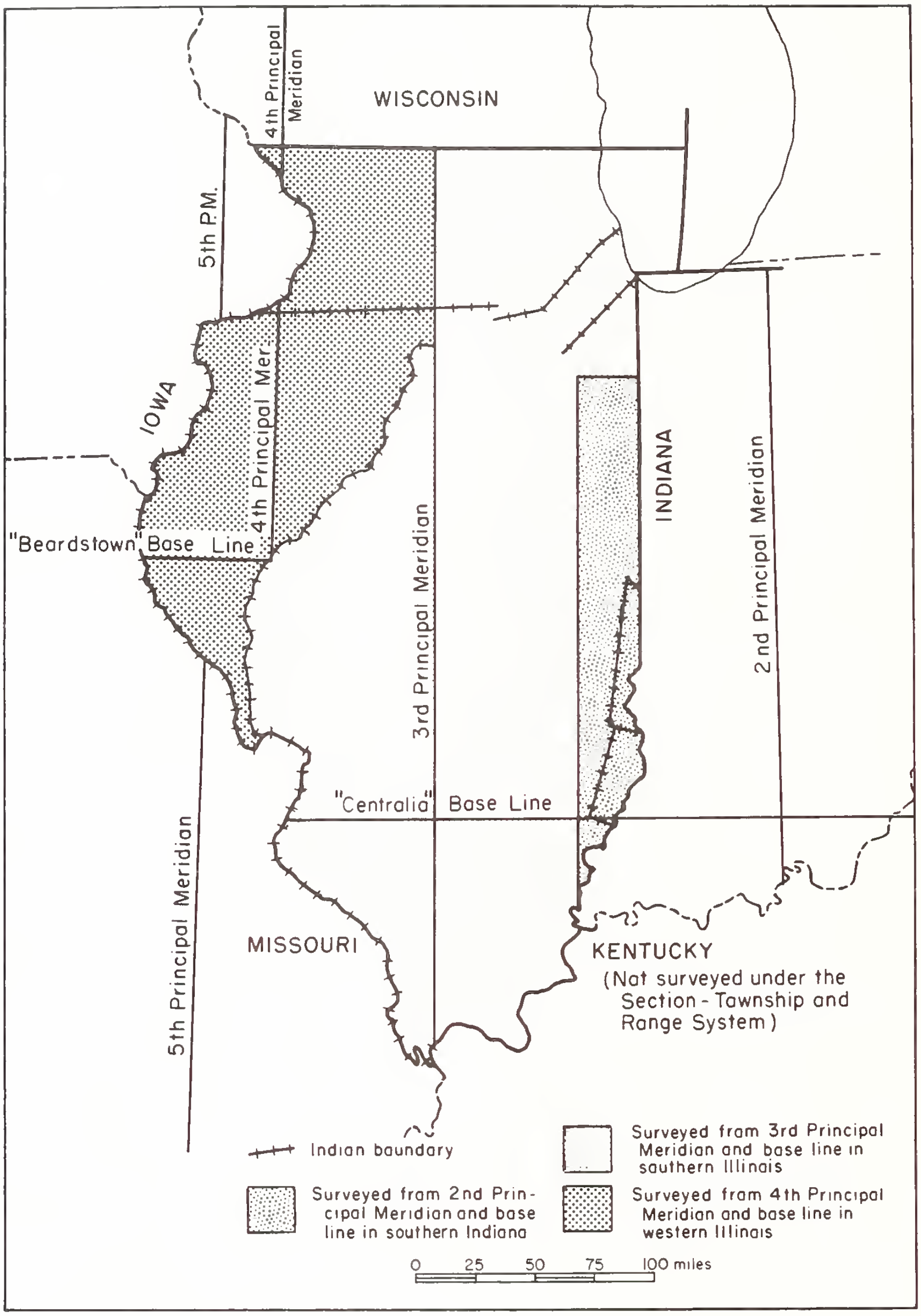


Figure 10 Principal meridians and base lines of Illinois and surrounding states.

the minor offsets were usually made at regular intervals of about 30 miles. Figure 11 shows what happened when the survey from the 2nd P.M. met the survey from the 3rd P.M. From Iroquois County south to White County, only narrow partial townships could be made where the two surveys met. These partial townships are all located in R11E, 3rd P.M., and in most places, are less than one section wide. North of the Illinois River only east ranges are measured from the 3rd P.M.; everything to the west in that region is measured east from the 4th P.M.

Closer at hand, note that the top row of sections in T29N, 4th P.M., are exceptionally short (approximately 0.2 miles) from north to south. What else is strange about T29N? What

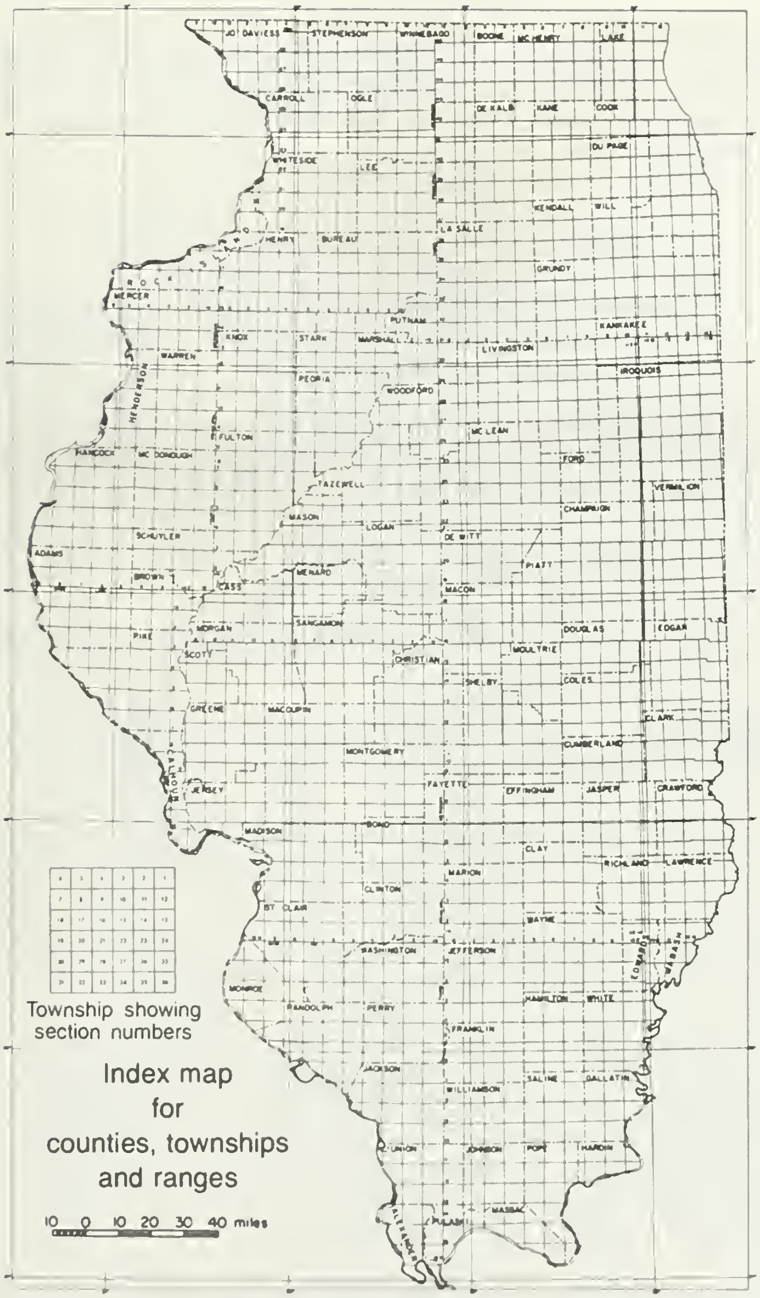


Figure 11 Index map of Illinois.

happened to the top 2+ rows of sections normally found in a township? Note also the western part of R1E, 4th P.M. The left (west) column of sections is missing and the next column to the east ranges from 0.3 mile wide at the state line to more than 0.4 mile wide at the south edge of the Galena Quadrangle map. The early surveyors must have had themselves a real time in this area. What do you suppose happened?

Get out your quadrangle maps and have some fun. What other anomalies can you find? If your supply of topographic maps is limited, contact the Illinois State Geological Survey (ISGS) for a free copy of the index to topographic maps of Illinois. When you decide which maps you want, you can purchase them from the ISGS and have some real fun as you become better acquainted with our state.

The elevation of the ground here is about 883± feet msl. We are standing on the loess-covered Ordovician Maquoketa Shale Group. A short distance to the north, we will find dolomite of the Ordovician Galena Group exposed. Note the changes in land surface, the topography, as we proceed along our route. Try to relate what you see to the type(s) of rock that underlie the area where you are at the time.

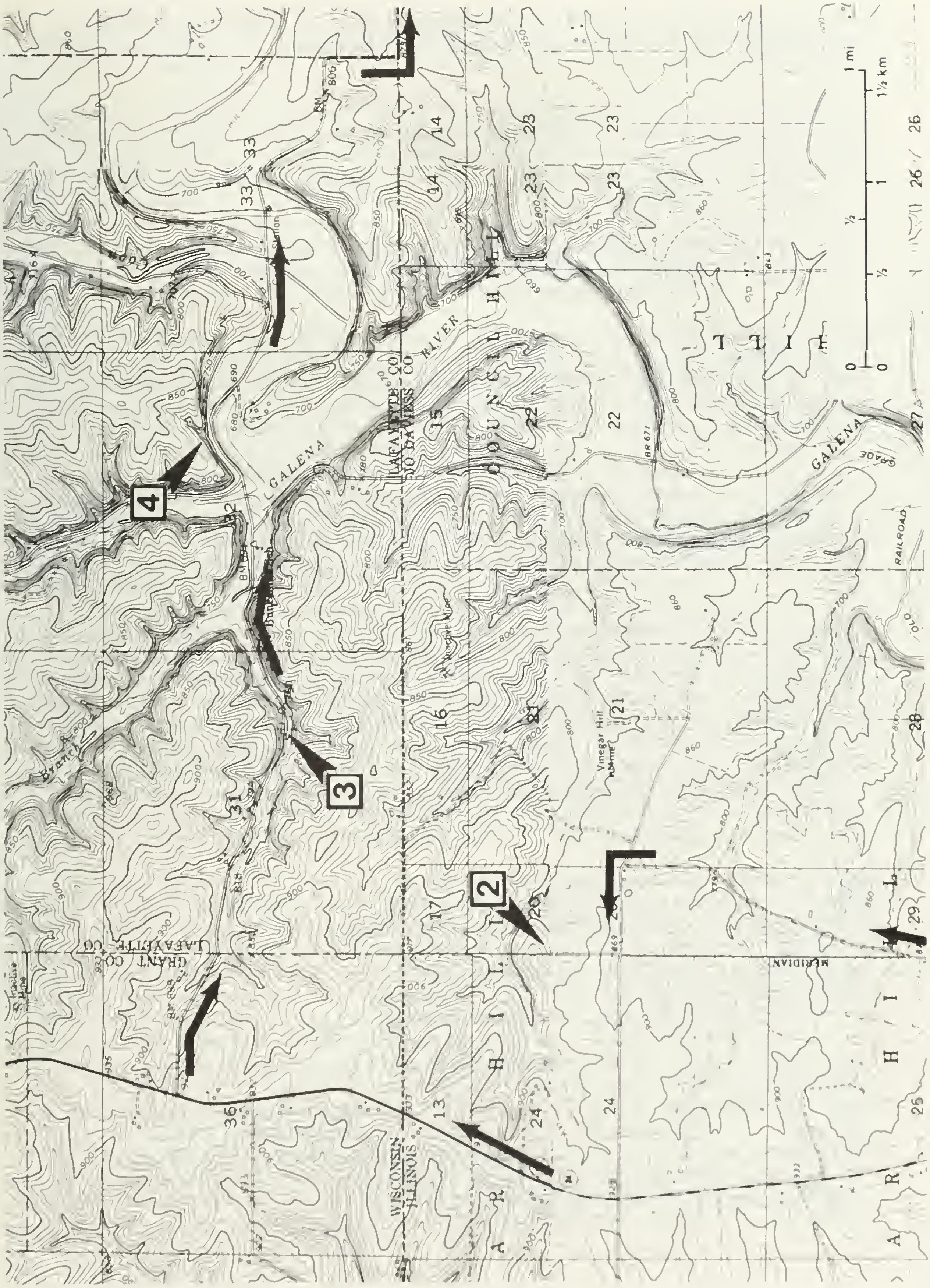
0.0	5.0+	Leave Stop 1. CONTINUE AHEAD (north).
0.55+	5.6	Galena dolomite is exposed in the left roadcut. As we approach the crest of the hill, the land surface on both sides of the road is very hummocky because of the old lead prospect pits.
0.7+	6.3+	The area to the right shows many of the prospect pits. The only thing it's good for is for pasture. As you can see from these pits, there was a lot of activity in this area at one time.
0.2+	6.5+	CAUTION: unguarded T-intersection. Visibility is limited. TURN LEFT (west) on West Furlong Road.
0.3	6.8+	CAUTION: narrow T-road lies to the right. TURN RIGHT (north) on North Three Pines Road.
0.35	7.15+	PARK in spaces provided. The mine entrance is a short distance down the slope in the frame building.
		Do not take hammers into the mine, and please do not use your fingers or any instrument to pick at the minerals that you see in the mine.

STOP 2 We'll visit the Three Pines Vinegar Hill Lead Mine (near center SW NE NE Sec. 20, T29N, R1E, 4th P.M., Jo Daviess County; Cuba City 7.5-Minute Quadrangle [42090E4).

According to the owner, Mr. Earl Furlong, the Three Pines Vinegar Hill Lead Mine, was first active between 1820 and 1830. The mine was operated intermittently along an east-west crevice, and during the late 1870's, yielded about 20 tons of lead ore (galena). The shaft was 47 feet deep, and ore was apparently produced from the Wise Lake Formation (fig. 3). For many years the mine was inactive, but during 1937 the mine was reopened by drifting (tunneling) back into the hillside from the east. About 1 ton of "cog mineral" (large crystals up to 1 foot across) was removed from the mine at that time.

Deeper mine shafts within a few hundred feet of this locality removed galena from the Wise Lake Formation and the upper part of the underlying Dunleith Formation. The Three Pines Vinegar Hill Lead Mine is situated north of Galena in what the early miners called the "crevice area," developed generally southwestward from the intersection of the Galena River and the Wisconsin-Illinois state line. The region is honeycombed with old shaft mines and shallow diggings that were worked for lead ore during the 1800s. A few old shafts within a radius of 1 mile from this locality produced several hundred tons of galena in the early days of mining. By the close of the 1800s, only small quantities of lead were being produced in the area, and most of this was recovered because it was associated with zinc ore (sphalerite, ZnS).

About 0.6 mile southeast of this location is the site of Vinegar Hill Mining Company, which was one of the richer producers in the area. The mine produced a total of 360,000 tones of ore, principally zinc, from 1908 to 1914, when it closed. Its shaft was about 200 feet deep because



GALENA
RIVER
COUNCIL HILL
CHARLES MOUND HILL
WISCONSIN
ILLINOIS
GRANT CO
LAFAYETTE CO
LAFAYETTE CO
JO DAVIESS CO
Vinegar Hill
RAILROAD
OLD GRADE
MERIDIAN
4
3
2
1 mi
1½ km

the zinc occurs at greater depths than the lead ore. Zinc ore is most abundant in the lower Dunleith, Guttenberg, Spechts Ferry, Quimbys Mill, and Grand Detour Formations, which are quite deep here.

0.0	7.15+	Leave Stop 2 and return to West Furlong Road.
0.35+	7.55	STOP: 1-way at T-intersection. TURN RIGHT (west) on West Furlong Road.
0.5	8.05	The pronounced hill about 6 miles ahead and slightly to the right is Sinsinawa Mound, an outlier of Silurian dolomite left behind when the Silurian escarpment was eroded southward.
0.3	8.35	STOP: 2-way at crossroad. TURN RIGHT (north) on SR 84.
0.75+	9.1+	Enter Wisconsin. To the right is an official historical marker erected in 1970 to describe the beginning of land surveying in Wisconsin:

The Point of Beginning

Late in 1831, when Wisconsin was still in Michigan Territory, Lucius Lyon, U.S. Commissioner on the survey of the northern boundary of the State of Illinois, set a post and erected a mound of earth six feet square at the base and six feet high, at a point one-half mile east of here to mark the intersection of that boundary and the Fourth Principal Meridian. The Wisconsin public land surveys were begun here in 1832 and were completed "up north" in 1867. Lyon surveyed 16 townships in Southwest Wisconsin in 1832-33, which opened this territory for settlement. In 1833, Michigan territory honored this veteran surveyor by electing him their Delegate to Congress. The post and mound he erected at this point were obliterated by fence and power line construction long ago, but the point is now preserved by a new concrete surveyor's monument. Every section corner monument in the state; the boundaries of each county, city, village, township, farm and lot; the position of roads, lakes, and streams, all were surveyed and mapped from this Point of Beginning.

CONTINUE AHEAD (north) on Wisconsin SR 80.

0.65+	9.75+	SLOW. Prepare to turn right.
0.1+	9.9	TURN RIGHT (east) on Buncombe Road.
0.45+	10.35+	CAUTION: narrow concrete culvert.
0.1	10.45+	CAUTION: narrow concrete culvert.
0.2+	10.7	To the right across the draw is an abandoned lead mine.
0.45+	11.15+	PARK along the roadside. CAUTION: narrow shoulder. FAST TRAFFIC.

Do not block farm lanes and gates. Stay along the north road shoulder at the exposure. You can see everything you need to from the roadway, *so do not climb up the bank.*

STOP 3 At this roadcut, we'll examine an exposure of Ordovician Dunleith Formation (SE NE NW SE Sec. 31, T1N, R1E, 4th P.M., Lafayette County, Wisconsin; Cuba City 7.5-Minute Quadrangle [42090E4]).

This roadcut exposes about 25 feet of the Dunleith Formation, one of the four formations of the Galena Group (fig. 3). As noted at Stop 1, the Galena Group strata contain the principal mineralized zones of the lead-zinc district. The Dunleith is about 125 feet thick in the Galena area. This exposure consists of thick, even beds of light brownish gray, finely crystalline, sucrosic (sugary-appearing) dolomite in the lower 20 feet; the thick beds are overlain by more thinly bedded strata. The dolomite is finely porous and vuggy with numerous fossil molds. Thin bands of irregular, light gray chert nodules occur along bedding planes. The abundant chert in the Dunleith is typical of the formation and distinguishes it from the overlying Wise Lake Formation, which otherwise is almost identical to it in color and physical properties.

The Dunleith is very fossiliferous, but the fossils are poorly preserved, consisting mainly of the internal casts of shells. Gastropods (snails) are the most abundant fossils, but pelecypods and brachiopods can be collected. The rock was probably deposited as limestone ($CaCO_3$) and at some later time altered to dolomite ($CaCO_3 \cdot MgCO_3$) by the addition of magnesium. This alteration or dolomitization of the rock was accompanied by recrystallization, which produced the sugary texture and destroyed the fossils.

Origin of dolomite To most geologists, the available evidence indicates that dolomite was originally deposited as limestone by the chemical precipitation of calcium carbonate ($CaCO_3$) and by the accumulation of calcareous remains of marine plants and animals. There is considerable evidence that the limestone was changed to dolomite, or dolomitized, at some time after its deposition.

During dolomitization, magnesium ions replace calcium ions in the atomic structure of the mineral calcite ($CaCO_3$). Carbonate rock is classified, on the basis of the degree of dolomitization, as limestone (0% to 10% dolomite), dolomitic limestone (10% to 50% dolomite), calcitic dolomite (50% to 90% dolomite) or dolomite (90% to 100% dolomite). In pure dolomite, the ratio of calcium to magnesium is about 1:1. The small amounts of ferrous (Fe^{++}) iron that usually replace some of the magnesium in dolomite produce the characteristic light brown color (iron carbonate) of most weathered dolomite formations. Recrystallization also occurs during dolomitization, and in many cases, produces a sucrosic (sugary) texture that is also characteristic of many dolomites. Because of this recrystallization, primary sedimentary structures, such as current features and fossil remains, are poorly preserved, if not completely destroyed.

To some geologists, the evidence indicates that dolomitization generally takes place soon after deposition, when unconsolidated limy sediments are still in contact with sea water. Magnesium in the sea water is exchanged for calcium in the sediments by a reaction with the sea water that bathes the upper part of the sediments. Other geologists have found evidence that after the limy sediments consolidated into limestone, dolomitization took place by a reaction with magnesium-rich formation water (connate water) trapped in the limy sediments or in associated sandstones and shales during deposition. Still other studies indicate that dolomitization is accomplished by groundwater that becomes charged with magnesium from the zone of weathering at the earth's surface. The magnesium-rich groundwater percolates through pores and cracks (joints) in the limestones, altering them to dolomite. There is other evidence that some ancient dolomite precipitated directly from sea water under special environmental conditions, thus some dolomites are primary in origin rather than secondary alteration products of limestone. However, the conditions required for primary precipitation of dolomite are generally not found in most marine environments where limestone deposition is occurring at present. Space does not permit evaluation of all theories proposed to explain dolomitization. Suffice to say that the processes are complex, and that there is more than one way to form dolomite.

The distinctive fossil, *Receptaculites,* is abundant in some beds. Because of its form, this most interesting fossil is commonly referred to as the "Sunflower Coral," although it is definitely not a coral nor even a sponge, as was once thought. At present it cannot be assigned to any known animal group.

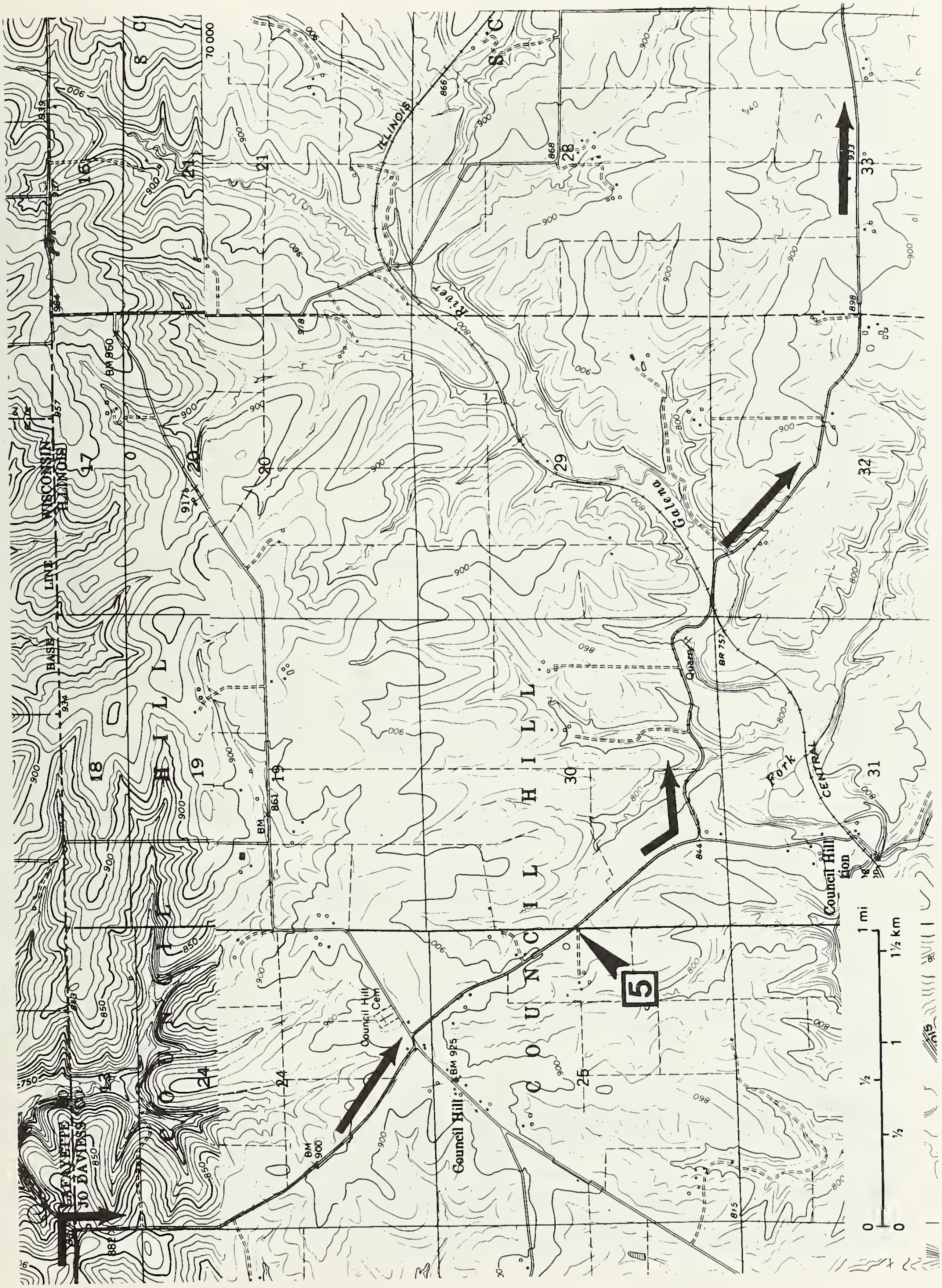
0.0	11.15+	Leave Stop 3. CONTINUE AHEAD (east). Outcrops of Dunleith can be seen on both sides of the road.
0.05+	11.25+	CAUTION: narrow concrete bridge. On the left after the bridge are the remains of several lead mines.
0.4+	11.7+	CAUTION: narrow bridge crosses over Scrabble Branch. SLOW. Prepare to stop.
0.15+	11.85+	T-road intersects from right. CONTINUE AHEAD (east).
0.1+	12.0+	Cross Bull Branch.
0.05	12.05+	CAUTION: T-road intersects from left. CONTINUE AHEAD and prepare to stop.
0.15+	12.25	PARK along roadside as close as you can to the cable. The road is narrow and traffic may be moderately heavy. STAY ALERT!

STOP 4 We'll examine the "Buncombe Section" exposed in the high bluff on the north side of the road. It features exposures of Dunleith, Guttenberg, and Spechts Ferry Formations (SE NE SW NE Sec. 32, T1N, R1E, 4th P.M., Lafayette County, Wisconsin; Cuba City 7.5-Minute Quadrangle [42090E4]).

Downcutting of the river has exposed the lower part of the Dunleith Formation and the underlying Guttenberg and Spechts Ferry Formations of the Galena Group. In the small draw on the left, the exposed section includes the following units:

	"Drab"	Gray to brown mottled, vuggy dolomite, cherty in zones; 10 feet+
Dunleith Formation (Fm)	"Gray"	Gray to buff, slightly vuggy dolomite; thin green shale partings; 13 feet
	"Blue"	Blue-gray dolomite, sandy; thin green shale partings; 6 feet
Guttenberg Fm	"oilrock"	Fine-grained, brown, thin- to medium-bedded dolomite and limestone, gray in lower part; wavy bedding planes; chalky on weathered surfaces; highly fossiliferous; thin red-brown shale layers; 13 feet
Spechts Ferry Fm	"Clay bed"	Clay, greenish, shaley, 1 foot

The Champlainian (middle Ordovician) formations have persistent, characteristic lithologies that are readily distinguishable in outcrops and in the subsurface, as mentioned earlier. Over the years of mining lead and zinc deposits, miners and drillers have given common names to these formations. The Guttenberg is called "oilrock" because some of the red-brown shales contain enough distillable petroleum to burn briefly when ignited with a match.


WISCONSIN
ILLINOIS
BASE LINE
COUNCIL HILL
Galena River
Council Hill Cem
Council Hill
Quarry
Fork
CENTRAL
ILLINOIS
5
1 mi
1½ km

Some zones in the Guttenberg are extremely fossiliferous. The fossils are rather difficult to collect because of the density of the rock, but with patience, one can collect specimens of a large variety of fossils: trilobites, gastropods, pelecypods, cephalpods, crinoids, bryozoans, brachiopods, and corals. Especially abundant are the brachiopods *Pionodema subaqueata, Dinorthis pectinella, Rafinesquina trentonensis, Sowerbyella curdsvillensis,* and *Strophomena filitexta.* For the most part, the original shell material of the fossils is no longer present. Excellent casts and molds of the fossils can be collected, however, by breaking the rock.

Origin of chert Like the origin of dolomite, this process is not completely understood by geologists. The chert was apparently not deposited in its present form at the same time as the dolomite, as evident from the fact that the chert is fossiliferous and exhibits many sedimentary structures that are also in the dolomite. Thus, the chert appears to have replaced the dolomite. Colloidal and finely divided particles of silica were probably deposited as the siliceous hard parts of sponges and microscopic plants and animals. Later, after solidification of the dolomites (or the limestone that changed to dolomite), this disseminated silica was dissolved, concentrated by solution, and redeposited as the irregular bands and nodules now present.

0.0	12.25	Leave Stop 4 and CONTINUE AHEAD (east).
0.45	12.7	R-intersection; BEAR RIGHT (east).
0.15+	12.85+	Cross Coon Branch.
0.15+	13.05	Cross Galena River. NOTE: a stream-gauging station is on the east side of the river south of the road.
0.85+	13.9+	CURVE LEFT (east) onto the Illinois-Wisconsin boundary road.
0.25+	14.15+	STOP: 1-way at T-intersection on a curve. TURN RIGHT (south) on North Road—no stop unless fast traffic approaches from the left.
1.15	15.3+	Many old "dog hole" mines are located on both sides of the road.
0.25+	15.6	STOP: 1-way at T-intersection. TURN LEFT (east) for 0.05 mile and then RIGHT (south) on West Council Hill Road.
0.65+	16.25+	PARK along the roadside near to the field openings on both sides of the road. From this vantage point, we can see the upland surfaces in the distance. CAUTION: FAST TRAFFIC! *Do not block or enter the gates and do NOT cross over the fences.*

STOP 5 We'll discuss upland surfaces in the Galena area (SW SW SW NW extended Sec. 30, T29N, R1E, 4th P.M., Jo Daviess County; Scales Mound West 7.5-Minute Quadrangle [42090D3]).

Topography of the field trip area Since the last Paleozoic sea withdrew from the Midcontinent at the end of the Pennsylvanian Period some 286 million years ago, or possibly as late as the end of the Permian Period nearly 245 million years ago, the Upper Mississippi Valley region has remained a land area. During this long interval of erosion, many hundreds of feet of Paleozoic strata have been stripped away. During the Pliocene Epoch between 5.3 and 1.6 million years ago, near the end of the Tertiary Period, the topography or relief of the region was reduced to a very low plain, the Dodgeville Peneplain.

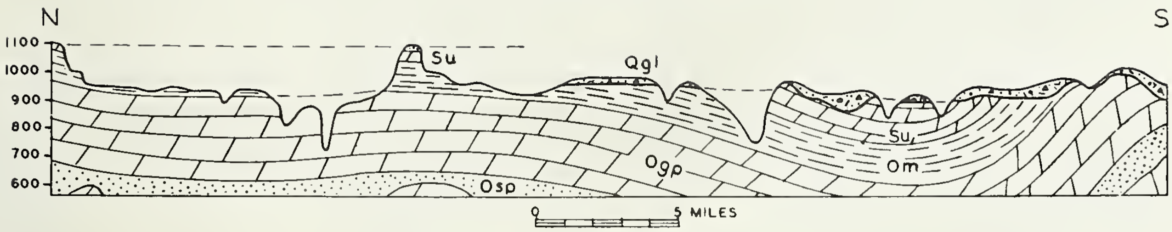


Figure 12 Cross section shows Dodgeville (upper) and Lancaster (lower) surfaces in northwestern Illinois from Apple River southeasterly to northwestern Carroll County. Qgl, glacial drift; Su, Silurian dolomite; Ogp, Galena-Plateville dolomite; Osp, St. Peter Sandstone (Horberg 1950).

A peneplain is a land surface worn down by stream erosion and mass wasting to a low, nearly featureless plain that gradually slopes upward from the sea. Such an erosion surface would take a very long time to develop, and it would be characterized by sluggish streams flowing in broad valleys. Bedrock structures, such as anticlines (strata arched upward), would have no influence on the topography but would be uniformly beveled.

Within the Galena Quadrangle, the slope of the Dodgeville Peneplain and the dip of the Silurian dolomite are the same. The erosion surface corresponds to the dipslope—a fact cited by some geologists who argue that the upland surface is not a peneplain at all but a structurally controlled feature that formed when strata less resistant than the Silurian dolomite were stripped away. Northward in Minnesota and Wisconsin, however, the surface bevels Ordovician strata that dip more steeply. Other arguments against the peneplain idea are the absence of a thick residual soil and the apparent control of present-day streams by bedrock joints, factors that should not exist if the region had been peneplained.

In the Driftless Area (unglaciated terrain) of Wisconsin, the Dodgeville surface is well preserved. In Jo Daviess County, Illinois, only remnants of the Dodgeville Peneplain are preserved as isolated, flat-topped ridges and knobs of Silurian dolomite (fig. 12). We can imagine the tops of these Silurian flats joined by a plane surface representing the former peneplain, sloping gently southwestward from about 1,235 to 1,000 feet msl.

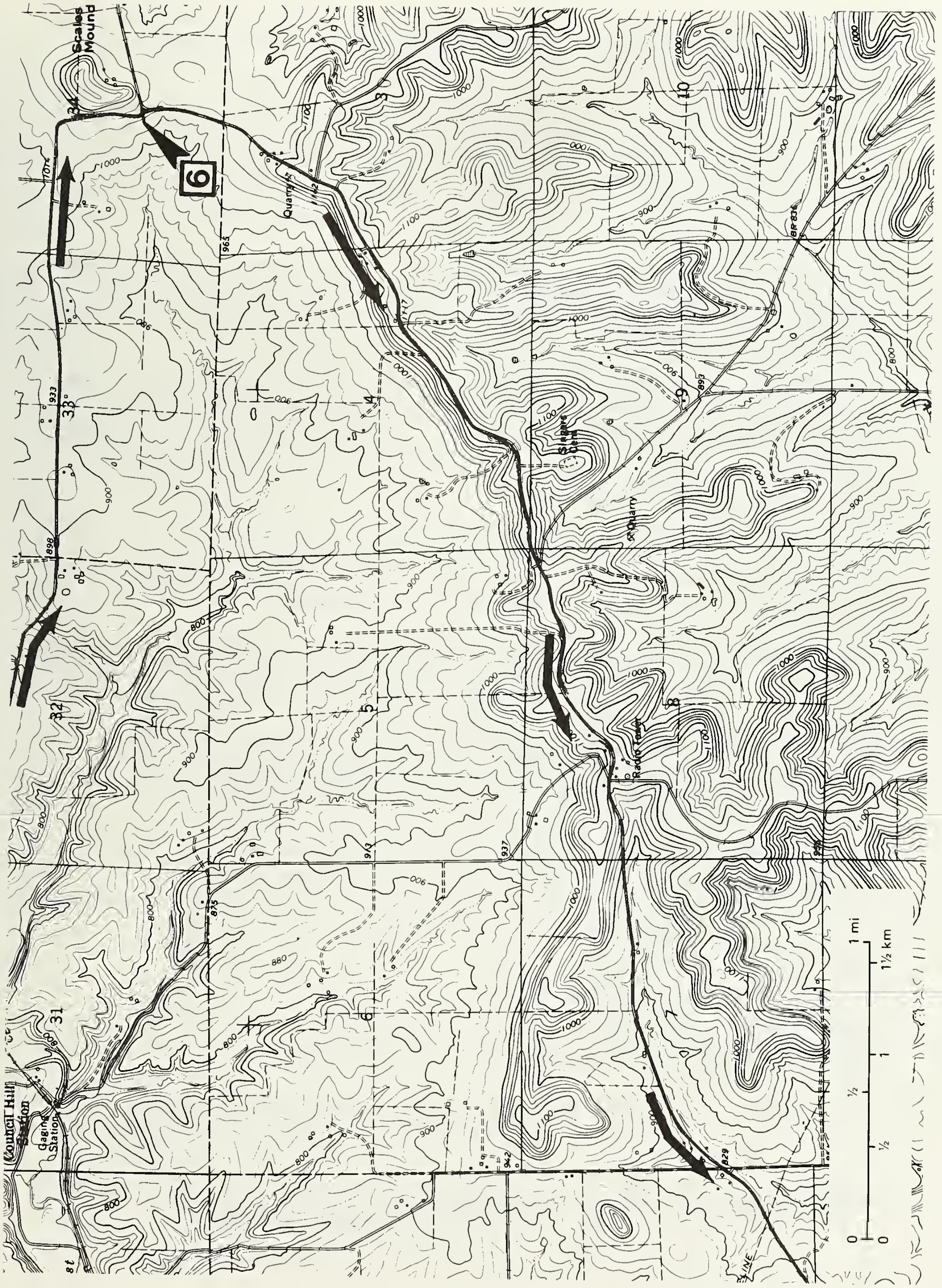
After the Dodgeville Peneplain was formed, the region was uplifted and another partial peneplain called the Lancaster Peneplain was eroded down to resistant strata about 200 feet lower. The Lancaster Peneplain is extensively preserved on the bedrock surface of northern Illinois. It is well developed in the Driftless Area, and east of the Driftless Area, it is a gently undulating surface covered by glacial deposits. It closely coincides with the top of the Galena Dolomite and slopes southwestward from an elevation of about 985 to 800 feet msl. The Galena area is near the south edge of the Lancaster Peneplain. The Lancaster surface, which slopes southwestward, is evident by the even horizon toward the east, north, and west. The skyline appears even because the nearly common summit levels merge when viewed from a distance.

The present topography of the Galena area is the result of stream dissection of the Lancaster Peneplain during the Pleistocene glaciations and modification of the dissected surface by glacial deposits. The Driftless Area is more rugged than adjacent areas because it was never glaciated; however, its mature topography is not a preglacial, erosion surface as was formerly believed. It was also eroded during the Pleistocene.

The relief of the bedrock surface is closely related to the establishment of the Mississippi Valley through the region during the earliest pre-Illinoian glaciation. Maximum relief was probably developed during the latter stages of pre-Illinoian glaciation when the valley was eroded to its maximum depth by meltwater. After that, the valley was alternately aggraded (built up) by

outwash and reexcavated during subsequent glacial and interglacial intervals. In the glaciated area to the east and south, till and outwash were deposited on the bedrock surface during the Illinoian glaciation. Loess was deposited on the uplands throughout the Upper Mississippi Valley region during the Illinoian and Wisconsinan glaciations. Deposition of a thick valley train in the Mississippi Valley during the late Wisconsinan Woodfordian and Valderan glaciations aggraded the valley to a level approximately 30 feet above its present floodplain. This aggradation also resulted in alluviation of the tributary valleys. Since the last glacier melted away, the Mississippi River and its tributaries have been deepening their valleys in the Wisconsinan alluvial deposits.

0.0	16.25+	Leave Stop 5 and CONTINUE AHEAD (southeast).
0.4	16.65+	Prepare to turn left ahead.
0.1+	16.8+	TURN LEFT (east) at T-intersection onto West Council Hill Road. The names of the roads in the area are a little confusing.
0.25	17.05	CAUTION: concrete culvert.
0.05+	17.1+	CAUTION: concrete culvert.
0.4+	17.55+	Intermittently operated quarry lies to the right. CONTINUE AHEAD (south).
0.15	17.7+	CAUTION: single, guarded Chicago, Central, and Pacific (CC) Railroad crossing.
0.15+	17.85+	CAUTION: narrow wooden bridge.
0.05-	17.9+	Ordovician dolomite is exposed on the left (east) side of the road.
1.1	19.0+	To the right (south) is a good view of the ridges capped by resistant Silurian dolomite.
1.1	20.1+	The hill we are approaching is Scales Mound. The town by that name is about 1 mile to the north and east. Charles Mound, the highest elevation (1,235 feet msl) in Illinois, lies about 3.1 miles to the left (northeast). The wooded area in the distance to the northeast is on the south slope of Charles Mound. You may be able to see a lone spruce tree close to the summit, if other trees between here and there don't mask it. The elevation at this T-intersection is 1,014 feet msl.
0.4	20.5+	Note the large blocks of Silurian dolomite protecting the crest of Scales Mound.
0.05+	20.6+	PARK along the roadside just before you enter the Y-intersection. Do NOT block mailboxes or driveways when you park. Walk east along the limb of the Y-intersection on the left (north) side to the top of the hill so that you can clearly see and hear traffic coming from both directions. Then cross to the south side for a good view of the ridge-top with the dolomite sticking out above the slope. You can examine the dolomite up close without crossing over the fence. When you get ready to cross the road again, ***stop, look, and listen*** before continuing back to your car.


Scales Mound
Council Hill Station
Gaging Station
Quarry
Radio Tower
6
1 mi
1½ km

STOP 6 We'll examine parts of the Silurian Edgewood and Kankakee Formations (SE SE NE SW and SW SW NW SE Sec. 34, T29N, R2E, 4th P.M., Jo Daviess County; Scales Mound West 7.5-Minute Quadrangle [42090D3]).

Scales Mound is capped by an outlier of the Silurian Kankakee Formation. The Kankakee Formation consists of cherty dolomite, which is quite resistant to erosion. The lower slopes of the mound are formed by the softer, argillaceous (clayey) Silurian Edgewood Formation. At the base of the mound along the roadcut, the soft Ordovician Maquoketa Shale is exposed. The gentle slopes in the foreground are also developed on Maquoketa shale, and beyond toward the north and west is the dissected Lancaster erosion surface on Galena Dolomite.

About 20 miles to the north, two other Silurian outliers, the Platte Mounds, are visible depending on where you are standing on the mound. Toward the west, Sinsinawa Mound stands prominently above the Lancaster Peneplain. Toward the southwest are remnants of the Silurian escarpment, which our route will take us over shortly.

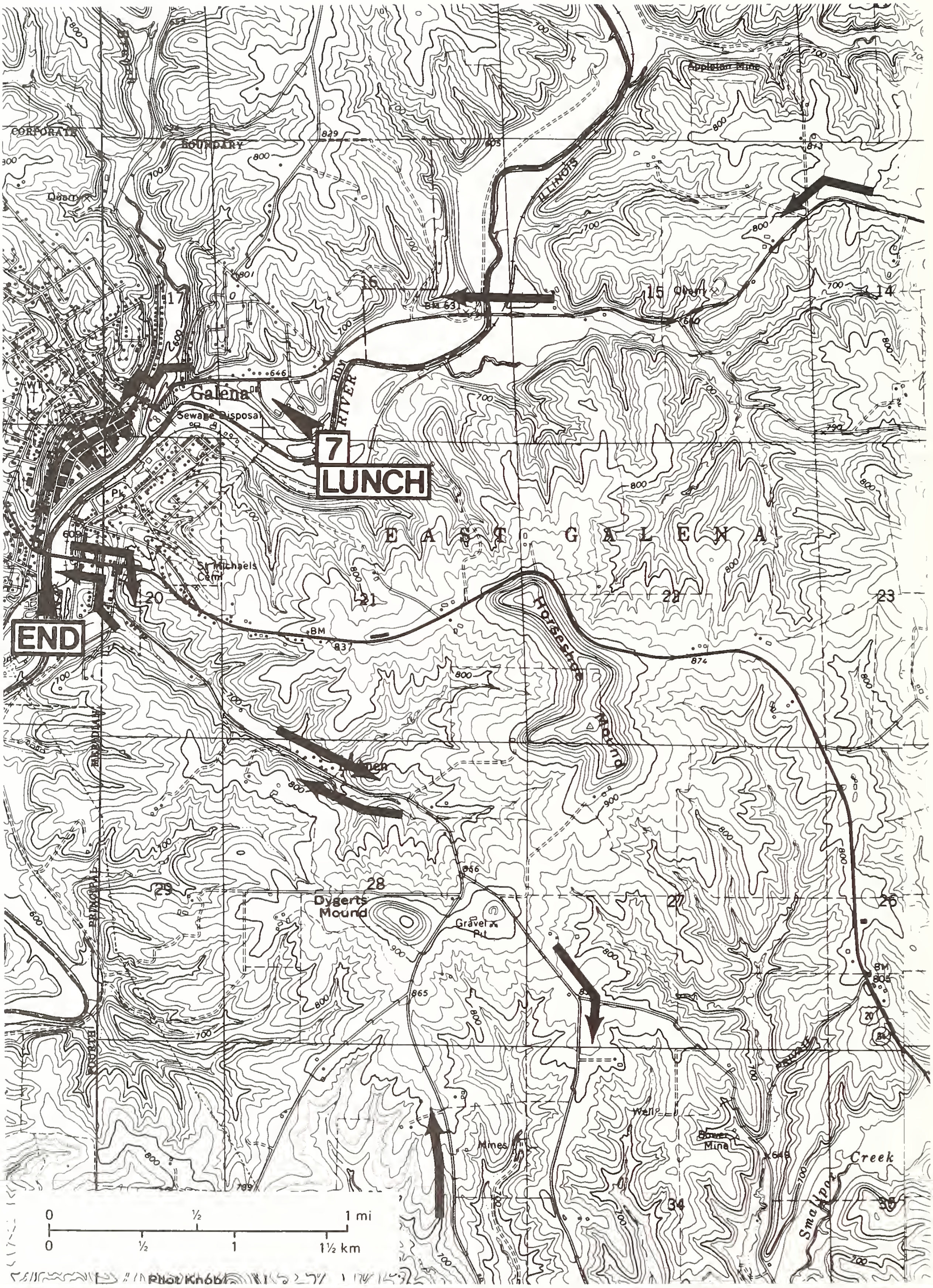
The Kankakee Formation exposed here consists of light tan, cherty, thin-bedded dolomite with wavy bedding planes. Outcrop surfaces are coated with brilliant orange algae. In places along the exposure, the bedding planes pinch out laterally into massive dolomite, which may represent small reefs. These contain fragments of stromatoporids, reef-building animals that are now extinct but may be related to the corals. Other fossils are scarce, but a few beds contain scattered fragments of silicified colonial corals, brachiopods, and crinoid columnals.

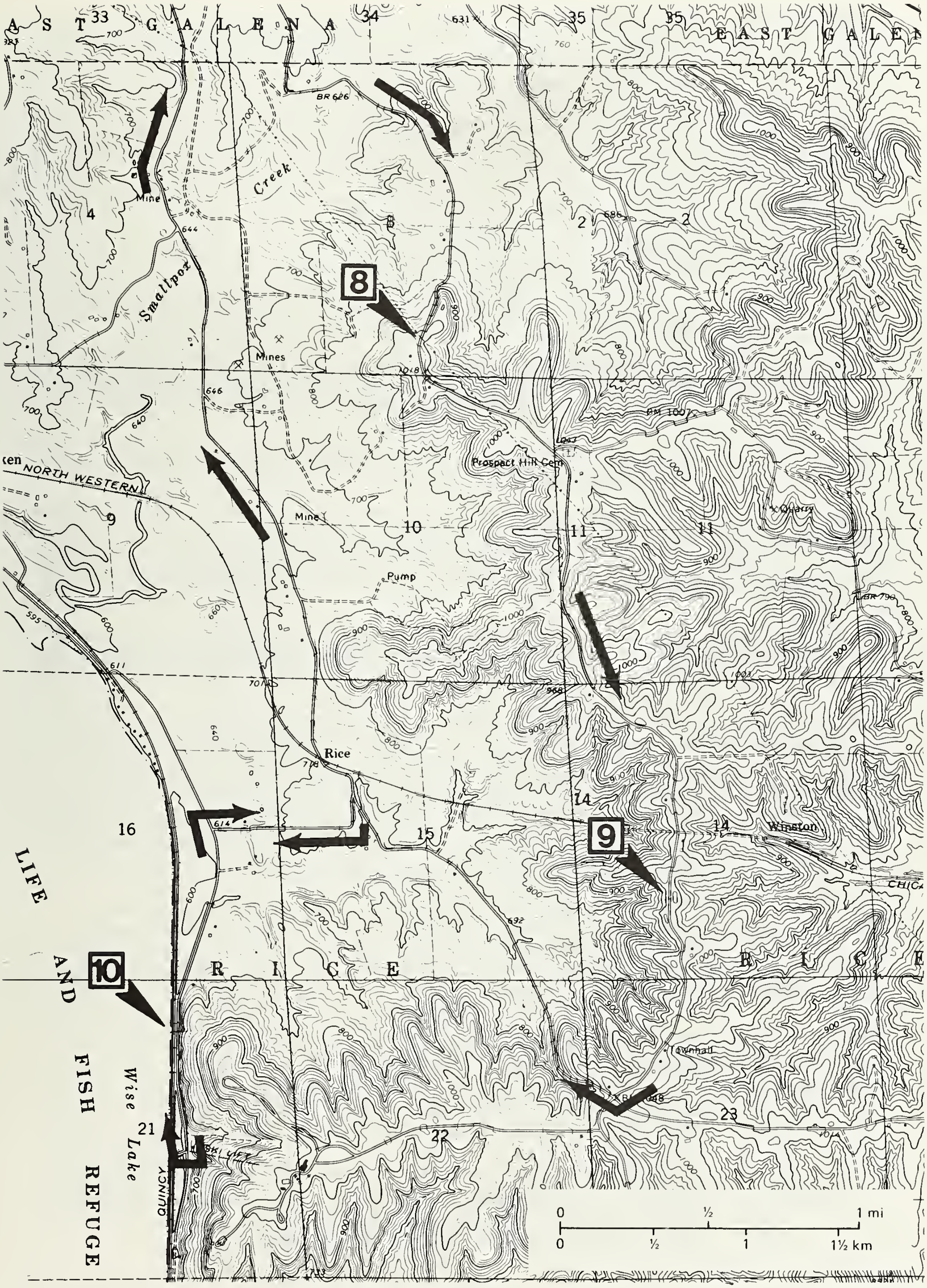
Note that large slump blocks have slid down across the underlying shale.

0.0	20.6+	Leave Stop 6 and CONTINUE AHEAD (south).
0.05-	20.6+	STOP: 1-way on the curve of stop 6. Visibility is fairly good straight ahead. CAUTION: look over your shoulder for oncoming traffic speeding over the brow of the hill. When safe, enter Stagecoach Trail heading south.
0.6	21.25+	To the right (north) are excellent views across the dissected Lancaster Peneplain underlain by Ordovician Maquoketa and Galena strata. The T-intersection from the left (east) is the highest elevation (1,142 feet msl) on the field trip.
0.4+	21.65+	Good view of the landscape to the left (south).
1.35+	23.05	To the left (south) chert residuum weathered from Silurian dolomite may be observed in the lower part of the roadcut.
5.35+	28.45	(CC) Railroad overpass.
0.05-	28.45+	Cross Galena River.
0.4+	28.9+	CAUTION: enter Galena and prepare to turn left.
0.4	29.3+	TURN LEFT (south) on the west side of the baseball diamond for the entrance to the city park and picnic area. PARK, *but NOT on the grass.*

STOP 7 Lunch will be enjoyed at Water Park (E2 SW and W2 NW SE SW Sec. 16, T28N, R1E, 4th P.M., Jo Daviess County; Galena 7.5-Minute Quadrangle [42090D4]).

0.0	29.3+	Leave Stop 7. CAUTION: heavy traffic. TURN LEFT (west).
0.35+	29.7	TURN RIGHT on Meeker Street and cross Hughlett Branch.
0.05+	29.75+	CAUTION: intersection. TURN LEFT (southwest) on Broadway.
0.05+	29.8+	STOP: 4-way. TURN LEFT (southeast) on Franklin Street.
0.05+	29.85+	TURN RIGHT (southwest) on Commerce Street.
0.1+	30.0	Old Market House State Memorial stands to the left. Constructed in 1845, the market house was the center of much buying and selling until about 1910. It also served as a municipal building with the surveyor's office and city council chamber located on the second floor. A couple of jail cells were in the basement. The city transferred ownership of the building to the State in 1947, and it was restored in 1955. At this museum, you can view a slide-cassette show about Galena's architecture, and a collection of pictures showing many of the old buildings. Free admission. Open daily 9:00 a.m. to 5:00 p.m. CONTINUE AHEAD (southwest) to the next intersection.
0.05-	30.05-	TURN RIGHT (northwest) on Hill Street.
0.05-	30.05+	STOP: 2-way at Main Street (1-way to right). CONTINUE AHEAD (northwest) up Hill Street.
0.05	30.1+	CAUTION: TURN LEFT (southwest) on Bench Street and pass the fire station and Turner Hall on the right.
0.1+	30.2+	The Galena/Jo Daviess County Historical Society and Museum, housed in the Daniel A. Barrows House built in 1858, is also located to the right. The *Italianate* building, designed by William Dennison who also designed the Ulysses S. Grant Home, contains thousands of artifacts from Galena's early history. Among the collection is Thomas Nast's famous Civil War painting, "Peace In Union." A new display on geology includes an excellent relief model of the area encompassing Galena, Scales Mound, and Elizabeth. You'll find this display on the second floor. There is a modest entrance fee. Open daily from 9:00 a.m. to 4:30 p.m.
0.25	30.45+	CAUTION: the descent from Bench Street is steep.
0.1	30.55+	STOPLIGHT: Main Street. TURN RIGHT and get in left turn lane.
0.05-	30.6	STOPLIGHT: Decatur Street (US 20 and SR 84). TURN LEFT and cross the Galena River.
0.1+	30.7+	Cross (CC) Railroad on the overpass.
0.05	30.75+	Prepare to turn right.
0.05+	30.85	TURN RIGHT (south) on Blackjack Road toward Blanding Landing and Chestnut Mountain Ski Resort.
0.1+	30.95+	R-intersection. BEAR LEFT (southeast) on Blackjack Road.


CORPORATE
BOUNDARY
Quarry
Galena
Sewage Disposal
7
LUNCH
END
ILLINOIS
RIVER
Appleton Mine
E A S T G A L E N A
St Michaels Cem
Horseshoe Mound
Dygerts Mound
Gravel Pit
FOURTH PRINCIPAL MERIDIAN
Bower Mine
Mines
Well
Smallpox Creek
0 ½ 1 mi
0 ½ 1 1½ km
Pilot Knob


EAST GALENA
EAST GALENA
Smallpox
Creek
Mine
Mines
Mine
Pump
Prospect Hill Cem
Quarry
NORTH WESTERN
Rice
Winston
CHICA
RICE
RICE
Townhall
LIFE AND FISH REFUGE
Wise Lake
QUINCY
8
9
10
0 ½ 1 mi
0 ½ 1 1½ km

0.4+	31.35+	Cross the creek.
0.35+	31.7+	Cross the creek. You are in the hamlet of Bremen. Farther along you will see old diggings close to the road.
0.55+	32.3+	Prepare to turn left part way up the hill.
0.15	32.45+	TURN LEFT (southeast) on North Irish Hollow Road.
0.55+	33.05+	BEAR RIGHT (south) on Rock Hill Road.
1.4+	34.45+	Cross Smallpox Creek on the concrete bridge.
0.5	34.95	The steep slope behind us was the Galena dolomite. We are now on the Maquoketa shale.
0.45	35.4+	The lower part of the Silurian dolomite exposed here forms a cliff that creates the steep grade of the road. CAUTION: pay attention to the road, which drops off steeply on the right side.
0.15+	35.6+	PARK along the roadway. SET YOUR BRAKE. Do not block the driveways and stay out of the yards.

STOP 8 From Sunset Point, we'll look north toward the Dodgeville and Lancaster Peneplains (NW Corner NE SW SE Sec. 3, T27N, R1E, 4th P.M., Jo Daviess County; Bellevue 7.5-Minute Quadrangle [42090C4]).

The view is excellent. The conspicuous mound toward the northwest is Pilot Knob, to the right of it is Dygerts Mound, and still farther to the right is Horseshoe Mound. This may help to orient you, as you recall viewing these mounds from the north on the way to Stop 1.

To the left (west), you can see the Mississippi Valley, which was a major channel for escaping glacial meltwaters. The bedrock of valleys such as this was greatly widened and deepened during times of greatest flood. When the meltwater floods were waning, these valleys were partially filled with outwash far beyond the ice margins. In the Mississippi Valley south of here near Savanna, the valley train is more than 300 feet thick. Many river valleys in areas covered by the ice were completely buried by glacial deposits. The meltwaters also cut new valleys and caused numerous changes in the drainage system, some permanent and some temporary.

Deposits of windblown silt, called loess, form the surface materials over extensive areas of Illinois. Loess mantles the ridge from here southward. During Pleistocene time, as now, the winds prevailed westerly, so loess deposits are thickest on the east sides of the broad, source valleys. The valley train of the Mississippi Valley was the source of loess in the Galena area. Along the bluffs, the loess is as much as 35 feet thick.

The Gray Mine is about 0.5 mile below us to the west-southwest. We will pass the site of this large abandoned mine later.

0.0	35.6+	Leave Stop 8. Continue ahead (south and east).
0.65	36.25+	CAUTION: T-road intersects from left next to the Prospect Hill Cemetery. CONTINUE AHEAD (south).
1.7	37.95+	PARK along the roadside. CAUTION: FAST TRAFFIC.

STOP 9 We'll be looking at some prominent landforms lying toward the west (SE SW NE SW Sec. 14, T27N, R1E, 4th P.M., Jo Daviess County; Hanover 7.5-Minute Quadrangle [42090C3]).

To the west is an excellent view of the Mississippi Valley and the Dodgeville Peneplain in Iowa. The discovery by ISGS geologists of early pre-Illinoian outwash high on the bluffs east of the Mississippi Valley near East Dubuque is evidence that the ancestral Mississippi River was probably not entrenched in its present valley in the Galena area until after that early glaciation. These outwash deposits consist of coarse gravel overlying lake sediments in small, shallow channels on the dolomite bedrock, 200 feet above the floodplain. The position of the valley from the vicinity of St. Paul, Minnesota, southward along the west side of the Driftless Area closely follows the margin of the early pre-Illinoian glacial deposits. Thus, it appears that the position of the valley is the result of the early pre-Illinoian glaciation, and the stream was established along the ice margin during the maximum advance of the glacier.

Just south of Galena, the Mississippi Valley cuts through a prominent north-facing escarpment (bluff) of Silurian dolomite. The front of the escarpment stands about 200 feet above the level of the Lancaster peneplain. This escarpment, or cuesta, is the erosional edge of the Silurian dolomite formations that dip gently southwestward off the Wisconsin Dome (figs. 1 and 12).

0.0	37.95+	Leave Stop 9 and CONTINUE AHEAD (south).
0.75+	38.7	STOP: 2-way at the crossroads. TURN RIGHT (west) from South Rock Hill Road onto West Blackjack Road. You will be descending a fairly steep hill.
1.25	39.95	CAUTION: sharp turn to the right. Galena dolomite is exposed in the roadcut.
0.2+	40.15+	CAUTION: Y-intersection. Make a SHARP LEFT TURN onto West Sand Hill Road.
0.2+	40.35+	Enjoy the good view of the Mississippi Valley ahead, as you start descending the hill.
0.35	40.7+	STOP: 1-way at T-intersection. TURN LEFT (south) on South River Road. The main line of Burlington Northern from Chicago to Minneapolis and St. Paul runs on the right, and the river is on the other side of the tracks.
0.7+	41.4+	PARK along the roadside. CAUTION: do NOT get close to the tracks—*speeding trains! Keep off the tracks! And do NOT enter any old mines!*

STOP 10 Outside an abandoned crevice mine in Galena Dolomite, we'll gather to talk about mining in the old days (near center W line SE NW NE Sec. 21, T27N, R1E, 4th P.M., Jo Daviess County; Bellevue 7.5-Minute Quadrangle [42090C4]).

For more than 1.5 miles, the river bluff is honeycombed with abandoned lead mines that may date from pre-Civil War Days (fig. 13). These deposits were very rich but small. The lead ore occurred in fissures along joints in the dolomite. A more detailed discussion of the crevice deposits is given in the section, *Zinc-Lead Deposits of Northwestern Illinois,* at the back of this field trip guide booklet.

Some mine entries are still open and are large enough to enter—*but DON'T!* As dangerous as these mines were when they were being worked, they are even more dangerous now.

A couple of the openings look as though they might meet back in the bluff. About 120 feet to the north, a couple of the mines look as though they might meet back in the bluff. One mine goes straight back into the bluff along one of the joints. The mine here trends northeast along a joint. So I'm assuming the two probably intersect a short distance into the bluff.

When you see fluorescent orange paint sprayed on a tree, look for an old mine opening on the slope above. With the foliage out, it will be very difficult to see the old openings. The Illinois Department of Mines and Minerals is involved in a program to seal the openings throughout the district. They have placed concrete seals over the tops of many small shafts in this area and plan to seal the vertical openings as well. Perhaps an inexpensive way could be found to prevent access to the mines, yet leave the openings for you to see. Bars might be used to keep people and large animals out. After all, the mine openings are part of the area's heritage.

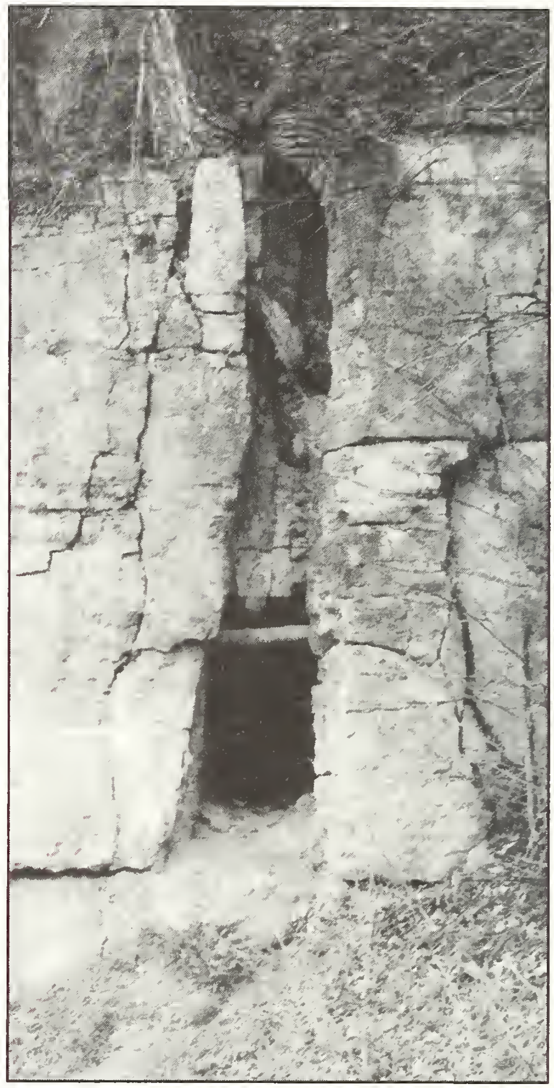


Figure 13 An early crevice mine exposed along River Road (photo by D. L. Reinertsen).

0.0	41.4+	Leave Stop 10 and CONTINUE AHEAD (south).
0.3	41.7+	CAUTION: you are entering the area of the ski lift for Chestnut Mountain Resort.
0.05+	41.8+	TURN AROUND at the south end of the parking area and RETRACE the route north.
1.05+	42.9+	TURN RIGHT on Sand Hill Road at the T-intersection.
0.55+	43.45+	STOP: 1- way at Y-intersection. BEAR LEFT (north) on South Blackjack Road.
0.1	43.55+	The road briefly runs on the bed of the old Chicago Great Western/Northwestern Railroad track that came through here from the 1/2-mile-long tunnel that was about 0.9 mile to the east. The crossing is called "Rice."
0.3	43.85+	Look to your left for a good view of the valley and bluffs with the erosion surfaces on the Iowa side of the river.
0.85+	44.75	The lane to the right now goes back to a farm, but it formerly went to the Bautsch Mine.
0.25	45.0	The large chat pile to the right is refuse from the mill at the Gray Mine.
0.35+	45.35+	Cross Smallpox Creek.

0.25+	45.65+	The old Blackjack Mine shaft was located 0.1 mile northwest of here. When the mine was operating during the late 1960s and early 1970s, an access road went under the road we're on. Ore was taken by truck to the Eagle Picher Graham Mine mill north of Galena for processing.
1.7	47.35+	As you're rounding a curve to the right just before a T-intersection from the left, you'll notice Dygerts Mound just ahead. This is one of the high points that you can see looking south from Galena.
0.35	47.7+	The large mound ahead is Horseshoe Mound. CONTINUE north on Blackhawk Road.
0.1	47.8+	You just passed the Irish Hollow Road where we turned southeast earlier. CAUTION: the left curve downhill is sharp.
0.55	48.35+	CAUTION: Hamlet of Bremen.
0.85+	49.25+	CAUTION: enter Galena.
0.2+	49.45+	STOP: 2-way at intersection with Decatur Street (US 20 and SR 84). CAUTION: visibility is poor to the right, and a sign obstructs visibility to the left. FAST TRAFFIC! TURN LEFT (west).
0.15	49.6+	To the right, you'll have an excellent view of downtown Galena. Cross Galena River and prepare to turn right at the stoplight.
0.1+	49.7+	STOPLIGHT stands at Main Street on the west end of the bridge over the Galena River.

End of the field trip to Galena.

Would you like to take in some of the sites that have a bearing on the geology of the area? TURN RIGHT on Main Street and go to Hill Street. TURN RIGHT for 1 block to the Old Market House, or TURN LEFT for 1 block to Bench Street, where you'll TURN LEFT again to get to the Galena/ Jo Daviess County Historical Society and Museum.

You could also CONTINUE AHEAD at the stoplight for about 6.7 miles on SR 84 to West Furlong Road, and then go 0.8 mile east to North Three Pines Road on the left leading to Three Pines Vinegar Hill Lead Mine, Stop 2.

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ILLINOIS STATE GEOLOGICAL SURVEY
Urbana, Illinois 61801

GEOGRAM 5
October 1975

ANCIENT DUST STORMS IN ILLINOIS

Myrna M. Killey

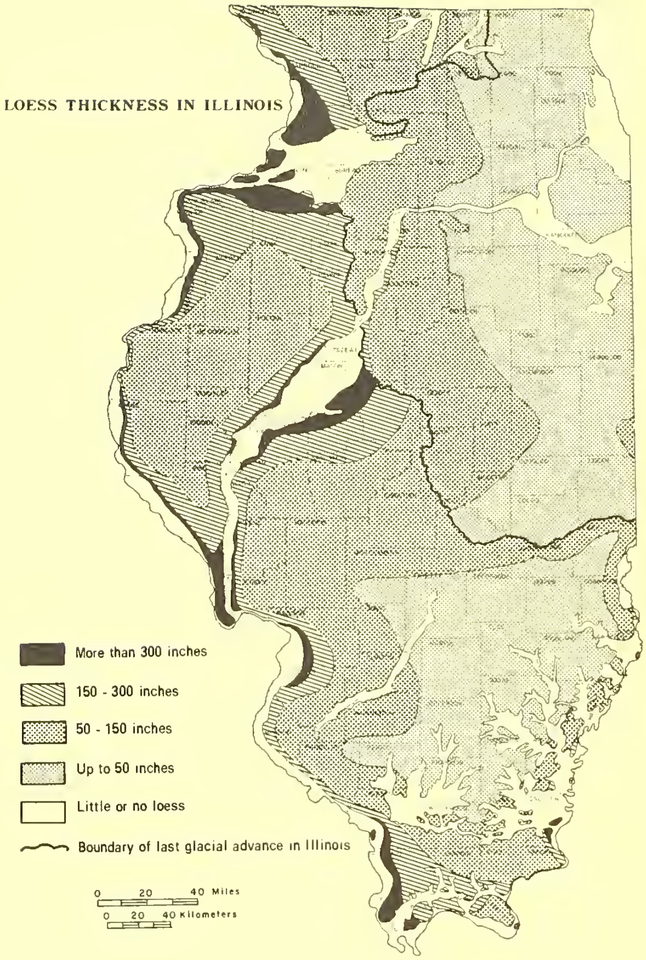
Fierce dust storms whirled across Illinois long before human beings were here to record them. Where did all the dust come from? Geologists have carefully put together clues from the earth itself to get the story. As the glaciers of the Great Ice Age scraped and scoured their way southward across the landscape from Canada, they moved colossal amounts of rock and earth. Much of the rock ground from the surface was kneaded into the ice and carried along, often for hundreds of miles. The glaciers acted as giant grist mills, grinding much of the rock and earth to "flour"—very fine dust-sized particles.

During the warm seasons, water from the melting ice poured from the glacier front, laden with this rock flour, called silt. In the cold months the meltwater stopped flowing and the silt was left along the channels the water had followed, where it dried out and became dust. Strong winds picked up the dust, swept it from the floodplains, and carried it to adjacent uplands. There the forests along the river valleys trapped the dust, which became part of the moist forest soil. With each storm more material accumulated until the high bluffs adjacent to major rivers were formed. The dust deposits are thicker along the eastern sides of the valleys than they are on the western sides, a fact from which geologists deduce that the prevailing winds of that time blew from west to east, the same direction as those of today. From such clues geologists conclude that the geologic processes of the past were much like those of today.

The deposits of windblown silt are called loess (rhymes with "bus"). Loess is found not only in the areas once covered by the glaciers but has been blown into the nonglaciated areas. The glaciers, therefore, influenced the present land surface well beyond the line of their farthest advance.

Loess has several interesting characteristics. Its texture is so fine and uniform that it can easily be identified in roadcuts—and because it blankets such a vast area many roads are cut through it. Even more noticeable is its tendency to stand in vertical walls. These steep walls develop as the loess drains and becomes tough, compact, and massive, much like a rock. Sometimes cracks develop in the loess, just as they do in massive limestones and sandstones. Loess makes good highway banks if it is cut vertically. A vertical cut permits maximum drainage because little surface is exposed to rain, and rainwater tends to drain straight down through it to the rock underneath. If the bank is cut at an angle more water soaks in, which causes the loess to slump down. Along Illinois roads the difference between a loess roadcut and one in ordinary glacial till is obvious. The loess has a very uniform texture, while the till is composed of a random mixture of rock debris, from clay and silt through cobbles and boulders.

Many loess deposits are worth a close look. Through a 10-power hand lens separate grains can be seen, among them many clear, glassy, quartz grains. Some loess deposits contain numerous rounded, lumpy stones called concretions. Their formation began when water percolating through the loess dissolved tiny

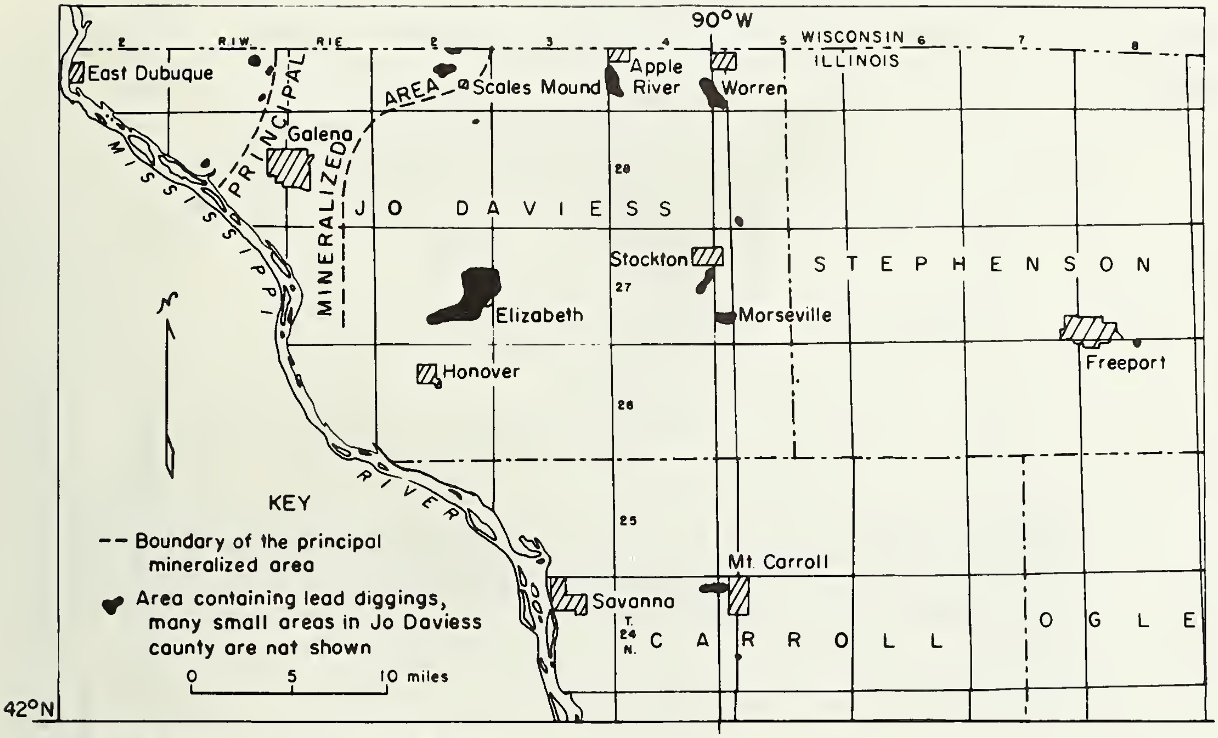


limestone grains. Some of the dissolved minerals later became solid again, gathering around a tiny nucleus or along roots to form the lumpy masses. A few such concretions are shaped roughly like small dolls and, from this resemblance, are called "loess kindchen," a German term meaning "loess children." They may be partly hollow and contain smaller lumps that make them rattle when shaken.

Fossil snails can be found in some loess deposits. The snails lived on the river bluffs while the loess was being deposited and were buried by the dust. When they are abundant, they are used to determine how old the loess is. The age is found by measuring the amount of radioactive carbon in the calcium carbonate of their shells.

Some of the early loess deposits were covered by new layers of loess following later glacial invasions. Many thousands of years passed between the major glacial periods, during which time the climate was as warm as that of today. During the warm intervals, the surface of the loess and other glacial deposits was exposed to weather. Soils developed on most of the terrain, altering the composition, color, and texture of the glacial material. During later advances of the ice, some of these soils were destroyed, but in many places they are preserved under the younger sediments. Such ancient buried soils can be used to determine when the materials above and below them were laid down by the ice and what changes in climate took place.

The blanket of loess deposited by the ancient dust storms forms the parent material of the rich, deep soils that today are basic to the state's agriculture. A soil made of loess crumbles easily and has great moisture-holding capacity. It also is free from rocks that might complicate cultivation. Those great dust storms that swirled over the land many thousands of years ago thus endowed Illinois with one of its greatest resources, its highly productive soil.



Zinc-lead district in northwestern Illinois.

ZINC-LEAD DEPOSITS OF NORTHWESTERN ILLINOIS

Principal Mineralized Area

The principal mineralized area in which the zinc-lead deposits in northwestern Illinois have been found occurs in Jo Daviess County in a belt from 5 to 10 miles wide and 15 miles long. The belt extends approximately northeast through Galena, from the Mississippi River to the Wisconsin stateline. Lead ore has also been mined near Elizabeth, Apple River, Warren, and at other places in Jo Daviess County. These occurrences increase the known mineralized district to include most of the county. Small amounts of lead ore are also reported to have been mined outside of this area near Freeport in Stephenson County and near Mount Carroll in Carroll County.

Stratigraphic Position of Ore Deposits

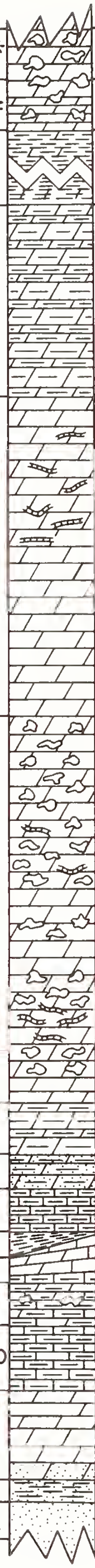
The zinc-lead ore deposits occur in the middle Ordovician carbonate formations of the Galena and Platteville Groups (Champlainian Series) of the Ordovician System. The major deposits of zinc ore (sphalerite, ZnS) are found in the lower part of the Galena Group, which includes the "Drab," "Gray," and "Blue" zones of the Dunleith Formation; the "oilrock," or Guttenberg Formation; and the "Clay bed," or Spechts Ferry Formation. Some deposits are found in the "Glassrock," or Quimby's Mill Formation, which is in the top of the Platteville Group. These deposits are mainly of the flat-and-pitch type described below.

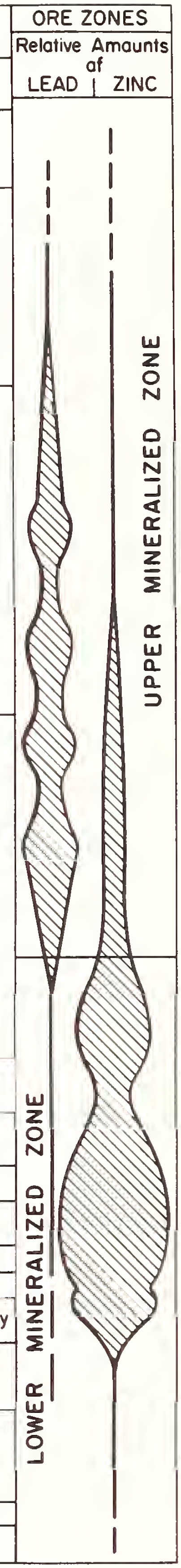
The major deposits of lead ore (galena, PbS) containing little associated sphalerite are found principally in the upper part of the Galena Group. This includes the top half of the Dunleith ("Drab") and the overlying Wise Lake Formation ("Buff"). These deposits are of the crevice type. Locally, the lead ore may grade into the mixed lead-zinc ore, especially in the lower part of the Wise Lake Formation.

Flat-and-Pitch Deposits

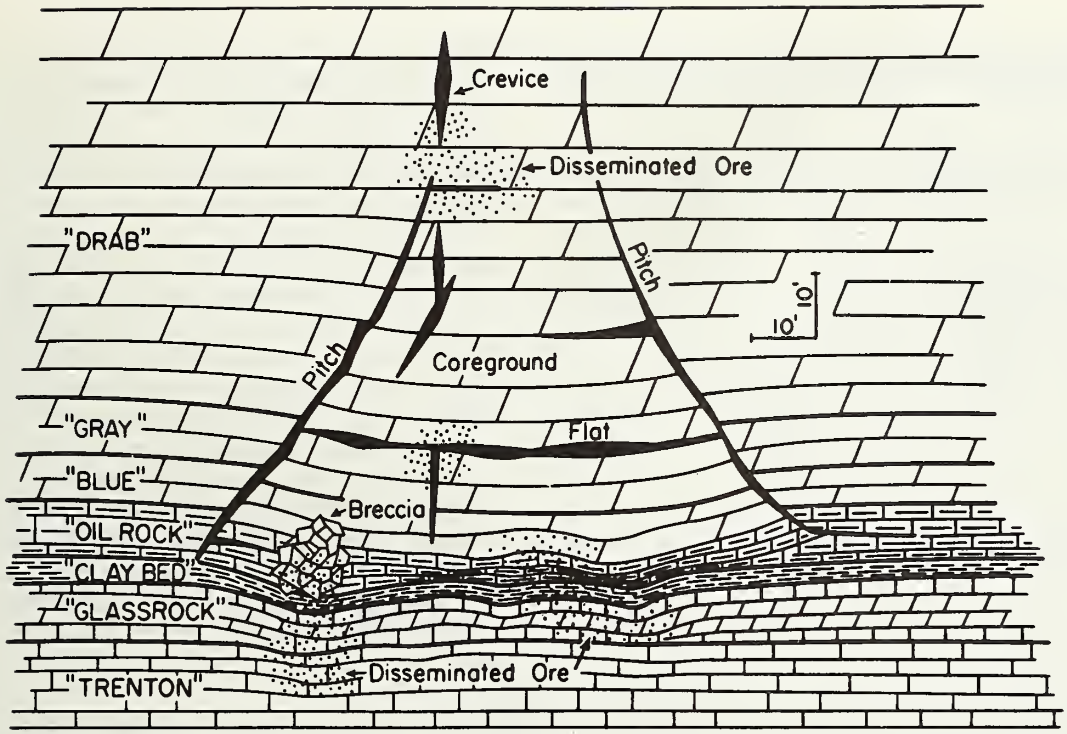
The flat-and-pitch deposits in the lower ore-bearing zone consist of flats, which are nearly horizontal, sheet-like bodies of ore between or parallel to the bedding planes of the strata, and pitches, which are similar to flats except they cut across the bedding planes. Pitches usually slope more than 45 degrees, and many become more steep upward and grade into vertical

SYSTEM	GROUP	FORMATION	MINING TERMS	THICKNESS	DESCRIPTION OF STRATA
Silurian				200±	Dolomite, gray, cherty, shaly
Ordovician	Maquoketa			110±	Shale, greenish gray; some dolomite
Ordovician	Galena	Dubuque	"Buff"	45	Dolomite, grayish tan, shaly
Ordovician	Galena	Wise Lake	"Buff"	75	*"Upper Receptaculites Zone"* Dolomite, tan
Ordovician	Galena	Dunleith	"Drab"	105	*"Middle Receptaculites Zone"* Dolomite, brownish gray, cherty *"Lower Receptaculites Zone"*
Ordovician	Galena	Dunleith	"Gray"	12	Dolomite, gray, shaly
Ordovician	Galena	Dunleith	"Blue"	8	Dolomite, blue-gray, shaly, sandy
Ordovician		Guttenberg	"Oil rock"	2-16	Limestone, brown, gray, shaly
Ordovician		Spechts Ferry	"Clay bed"	0-6	Shale, green, limy
Ordovician	Platteville	Quimbys Mill	"Glass rock"	1-18	Limestone & Dolomite, brown
Ordovician	Platteville	Grand Detour	"Trenton"	5-15	Limestone & Dolomite } gray, shaly, cherty
Ordovician	Platteville	Mifflin	"Trenton"	10-20	Limestone, gray, shaly
Ordovician	Platteville	Pecatonica	"Lower Buff"	20	Dolomite, brownish gray
Ordovician	Ancell	Glenwood		5	Shale, greenish, sandy
Ordovician	Ancell	St. Peter		20-300	Sandstone, white





Generalized sequence of strata in the Galena area.



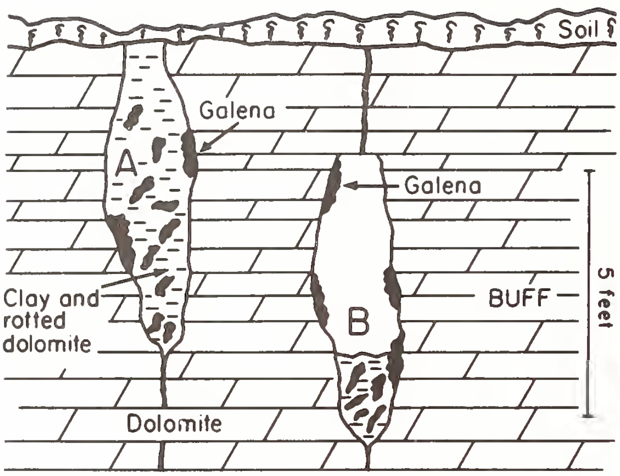
Flat-and-pitch ore bodies.

crevices; some flatten downward. The mineralized rock between pitches bounding an ore body is called the coreground.

Flat-and-pitch deposits are associated with small synclinal structures, which trend northwest, northeast, or east. Between pitches bounding an ore body, the oilrock and Glassrock are thinner than usual, apparently because of dissolution, and the overlying strata have sagged to form the synclinal structure. This sagging opened up the fractures, which became mineralized. The mineralized sags are usually 50 to 200 feet wide, but they may be as wide as 300 feet and extend longitudinally for thousands of feet in a straight line or in an arcuate manner. Usually, the minable thickness is about 40 feet, but sometimes it is thicker. There are many variations in the shape or character of these deposits. The ore generally occurs as fissure-filled deposits, but in the oilrock and Glassrock there are also disseminated-type deposits. Rarely, the ore will assay as high as 20% zinc, but 10% zinc is considered rich ore and 3% to 4% ore is considered minable. In some deposits, minable ground is confined entirely to the pitches, but parts of the coreground are also minable. Minerals, other than galena, associated with zinc ore include pyrite (FeS_2), marcasite (FeS_2), and calcite ($CaCO_3$). Above the water table, where oxidation has occurred, secondary minerals occur, including cerussite (lead carbonate, $PbCO_3$), anglesite (lead sulfate, $PbSO_4$), smithsonite (zinc carbonate, $ZnCO_3$), and limonite (iron oxide, $2Fe_2O_3{\cdot}3H_2O$).

Crevice Deposits

The crevice deposits of the upper mineralized zone occur as fissure fillings along joints that are oriented mainly in an east-west direction. The crevices are actually vertical fissures, or cavities, that were opened up along the joints by solution of the dolomite. Along a typical crevice, the minable ore occurs as pods or lenses, which range from a few feet to a few hundred feet long, scattered along the strike of the joints. The ore bodies are generally only a few inches to a few feet wide, but where there are two or more closely spaced crevices, they extend over widths of 30 feet or more. The ore is usually pure galena, but locally it may grade to mixtures of galena and sphalerite.



Crevice ore bodies. Crevice A reaches the ground surface and is filled with clay; B is only partly clay-filled.

Shallow crevice deposits were the principal source of lead ore in the United States between 1820 and 1865. These deposits were easily discovered in partial exposures along stream valleys. They were also discovered by the presence of residual accumulations of ore where erosion had intersected mineralized joints. In some cases, the topographic expression of crevices as shallow depressions led to the discovery of ore bodies. When these easily exploited deposits were depleted, lead ore production declined sharply. During the later years of production, zinc ore was the chief mineral commodity of the area, and it was obtained almost exclusively from the larger, deeper flat-and-pitch deposits. The last operating mine in northwestern Illinois, which was located south of Galena, was closed in 1973.

Origin of Ore Deposits

The origin of the ore bodies is still in question. An early theory that was widely accepted is the "cold water theory." In this theory, lead and zinc minerals were assumed to be present in trace quantities disseminated throughout the Galena Dolomite or higher rock units. The lead and zinc were originally supposed to have been deposited with the carbonate rocks when they were precipitated from the ancient Ordovician sea more than 400 million years ago. Percolating groundwater then dissolved the lead and zinc minerals from these rocks and carried them downward to be reprecipitated in openings in the strata where the ore is now found.

The theory now generally favored by geologists is emplacement by warm solutions emanating from strata buried deep in the Illinois Basin. The warm, mineralized solutions ascended until they encountered the cavernous, jointed Champlainian (middle Ordovician) rocks that had the proper temperature-pressure conditions to allow the precipitation of the lead and zinc sulfides. The neutralizing effect of carbonate-rich groundwater on the acid-sulfide bearing solutions could also have been partly responsible. These ideas may explain why the ore bodies are restricted to such a narrow vertical interval of Ordovician strata. However, the absence of deep downward extensions of ore and major faults that could have provided access to the rising solutions has not yet been resolved.

The open fissures in which the crevice ores were deposited and the synclinal structures associated with the flat-and-pitch ore bodies are solutional in origin and were formed before ore emplacement. Whether solution was by meteoric groundwater or by warm solutions from depth has not been definitely determined. If the latter is true, the openings may have been formed contemporaneously with ore deposition.

Prospecting for Ore Deposits

The long, fairly narrow ore bodies in the Upper Mississippi Valley zinc-lead district, especially the deeper ore bodies, are difficult to find. To extend the life of the mining district, new reserves must be found. Geophysical and geochemical methods have been used in the exploration for ore deposits, but with limited success. Drilling is the most commonly used means of prospecting for lead and zinc ores and is currently the most effective method of searching for the deep ore bodies. Drilling is used to explore the trends of known ore deposits and to search for new ore bodies in previously untested areas.

Most prospecting for lead and zinc ores in northwestern Illinois has consisted largely of drilling in areas of old shallow lead diggings, along the trends of known deeper ore bodies, and in the vicinities of occasional water wells that happen to penetrate ore. Wildcat holes drilled in un-

proven ground outside areas of known ore deposits have been relatively few. Many interrelated geologic factors must be evaluated by the geologist before deciding where to drill such exploratory holes.

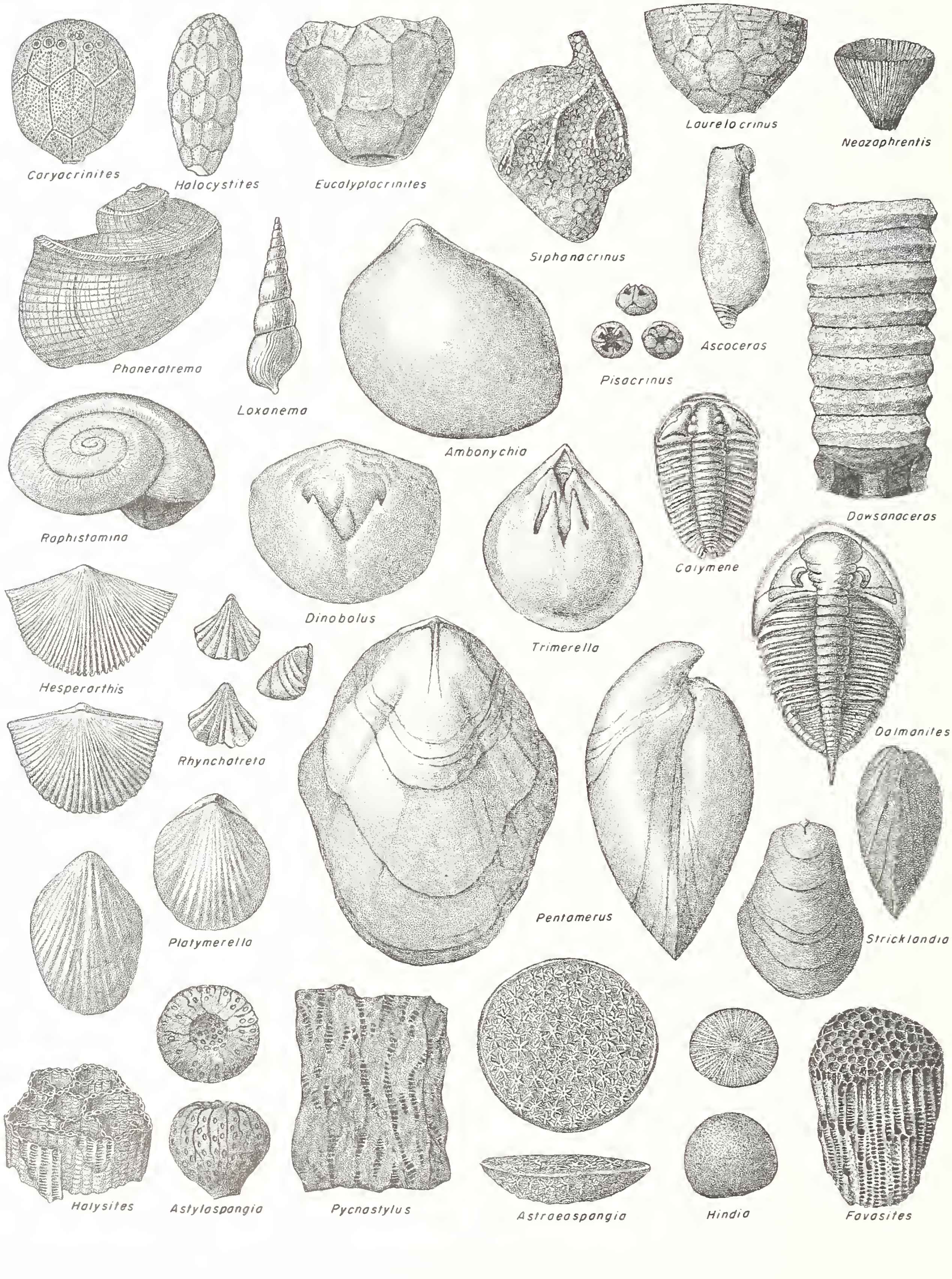
There are two principal methods of drilling deep holes: churn drilling and rotary drilling with a diamond bit.

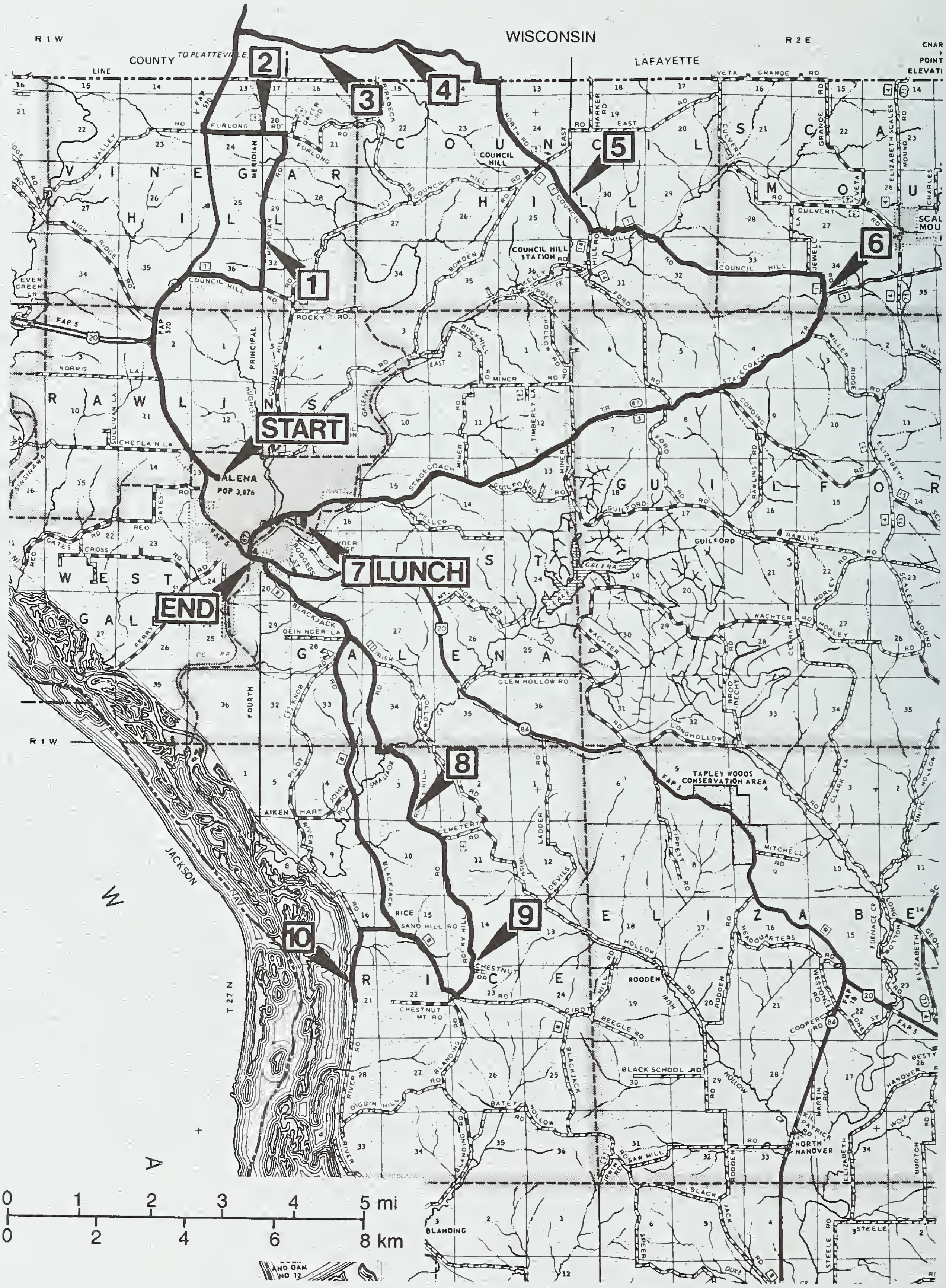
Churn drilling Churn drilling, also known as cable-tool drilling, is much less expensive than diamond drilling and has been widely used in the zinc-lead district for deep prospecting. Vertical holes 6 inches in diameter are drilled by a heavy steel rock bit suspended from a steel cable that is attached to the controlling machinery at the surface. The heavy bit is alternately lifted and dropped, and the rock is penetrated by the repeated blows of the bit. The broken rock is periodically bailed from the hole, and samples of the rock chips are saved for examining or assaying.

Diamond drilling Diamond drilling provides better rock samples than those obtained by churn drilling, if core recovery is good. The cores obtained are continuous samples, or a column, of the rock interval penetrated by the bit. In soft or fractured rock, often in critical zones of mineralization where samples are most desired, no sample may be recovered in some intervals because of poor core recovery. A definite advantage of diamond drilling is the ability to drill inclined holes. Drilling is accomplished by means of a small-diameter diamond bit attached to a column of pipe called the drill stem. The bit cuts through the rock when the drill stem is rotated by the power machinery at the surface. Water or a water-oil mixture is pumped down the inside of the drill stem under pressure to cool and lubricate the diamond bit. The water also flushes out crushed rock from the bottom of the hole and carries it up the drill hole to the surface. The rock core enters the hollow drill stem, where it is surrounded by the coolant as the bit cuts downward, and the core remains there until it is retrieved when the drill stem is pulled out of the hole. The diameter of the drill stem and bit are usually decreased periodically as the hole deepens, depending upon the depth to be drilled.

ORDOVICIAN FOSSILS

REPRESENTATIVE SILURIAN FOSSILS FROM NORTHWESTERN ILLINOIS





WISCONSIN
COUNTY LINE
LAFAYETTE
TO PLATTEVILLE
R 1 W
R 2 E
START
GALENA
POP 3,876
1
2
3
4
5
6
7 LUNCH
8
9
10
END
VINEGAR HILL
RAWLINS
COUNCIL HILL
SCALES MOUND
GUILFORD
WEST GALENA
EAST GALENA
ELIZABETH
RICE
COUNCIL HILL STATION
TAPLEY WOODS CONSERVATION AREA
NORTH HANOVER
JACKSON
T 27 N
0 1 2 3 4 5 mi
0 2 4 6 8 km